Taunton River. As a protection in case of a severe flood, this tunnel is made somewhat larger than is necessary for sewage alone, and is also connected with the cold-water channel, thereby making possible a flood discharge greater than can now be conveyed by the existing river channel between the Watuppa Dam and tidewater. This portion of the river bed is badly obstructed by various deposits and is contracted by the construction of buildings alongside and over it. Suitable provision for longitudinal expansion is made in the conduit, and special precautions are taken to allow for the independent movement of the hot-water channel.

One of the chief advantages of the conduit is the opportunity it provides for increased fire protection for the mills along the river. The abundant supply of water in the cold-water channel can be readily utilized for fire protection, not only for the district in the immediate vicinity of the conduit, but also in the portion of the city lying along the river valley. The district to which this additional fire protection can be secured includes the central business section of the city, in addition to the manufacturing district bordering the river. The advantage of this additional fire protection is particularly important because of the limitations of the present domestic water supply.

Another important advantage of the plan, so far as the water-supply is concerned, is that by its capacity of lowering the lake to considerably lower levels than can be done through existing means, a far greater storage capacity of the lake is made available and a regular daily supply of 20,000,000 gal. throughout the year can be obtained, this being equivalent to the average yield of the watershed. Under the conditions now existing the daily water-supply may fall as low as 5,000,000 gal.

In addition to the design of the main conduit numerous branch conduits to supply the various mills have been planned, as well as a complete system of sewers for the unsewered portion of the city adjoining the stream, and storm drains where needed. Only a limited portion of these sewers and drains need be built at the outset.

In the process of the investigation considerable attention was given to the separation of oil from the condenser water to prevent its being discharged into the pond, thereby forming a nuisance because of its deposits along the shore of the pond. Experimental studies were conducted on this topic in the laboratories of the Massachusetts Institute of Technology, which resulted in establishing the size and type of the oil-separating basin. Similar study was given to the question of cooling this hot water to prevent undue heating of the lake water near the cold-water intake.

It was found that a cooling basin sufficient in size to permit of cooling the discharged water in very hot weather to the same temperature as the lake was impracticable. The cooling basin as designed will, however, have considerable effect in this direction, and its outlet into the lake is sufficiently remote from the cold-water intake to insure that the partly cooled water will not reach the intake before thorough mingling with the lake water; it will therefore have sufficient additional cooling to make sure that the water reaching the mills will be cool enough for condenser purposes under any conditions that may arise.

The plan also contemplates as a necessary part of the abolition of the nuisance the filling of the entire area of the flats. This will result in the redemption of 146 acres of land, which will immediately become available for manufacturing and civic purposes.

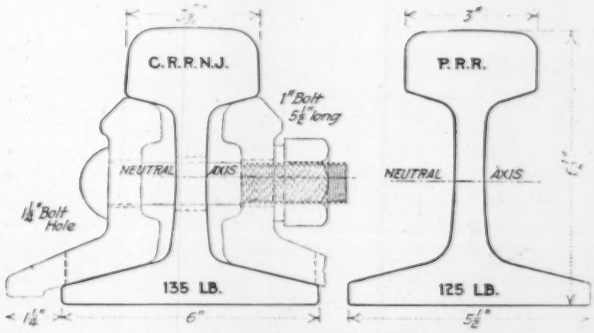
The total estimated cost of construction is $2,592,500, and in addition to this the engineers have made an allowance of $100,000 for damages and $250,000 for general expenses, bringing the total gross cost up to about $3,000,000. As an offset to this it is estimated that the value of the reclaimed land will be $800,000 and the benefits accruing to the mills $1,000,000, thus reducing the cost to the city to somewhat over $1,000,000.

According to the legislative act, the project must be adopted or rejected by the city council within thirty days of the receipt of the report. The project has already been approved by the Massachusetts State Department of Health.

Two Heavy Rail Sections

Rails heavier than 100 lb. per yd. are exceptional, and have been applied mainly where conditions of curvature and heavy traffic combine to cause severe stress and wear upon the track. The Pennsylvania R.R., however, is introducing a 125-lb. rail for general use on its busy main lines, and the New York Central R.R. is using a 105-lb. rail for similar lines.

The heaviest rail now in use is the 135-lb. rail of the Central R.R. of New Jersey. This was adopted a few years ago and is now in service on about 40 mi. of track. The Pennsylvania R.R. has more recently adopted its 125-lb. rail. Last year 15,000 tons of this section were laid, covering about 75 mi., and the 1915 contracts call for 37,500 tons.



DESIGN OF RECENT HEAVY RAIL SECTIONS

	C.R.R. of N.J.	Penna. R.R.
Weight per yd.	135 lb.	125 lb.
Height	6¼ in.	6¼ in.
Width of base	6 in.	5½ in.
Width of head	3 5/32 in.	3 in.
Sides of head	Sloped	Vert.
Depth of head	2 in.	1½ in.
Depth of web	3 9/32 in.	3 13/32 in.
Depth of base	1 7/32 in.	1 7/32 in.
Thickness of web	½-in.	21/32 in.
Radius of		
Head	14 in.	12 in.
Top corners	½ in.	7/16 in.
Bottom corners	3/16 in.	1/16 in.
Sides of web	14 in.	16 in.
Top fillets	½ in.	½ in.
Bottom fillets	½ in.	½ in.
Corners of base	½ in.	1/16 in.
Head	40.28%	38.9% (4.73 sq.in.)
Web	21.90%	20.3% (2.47 sq.in.)
Base	37.82%	40.8% (4.95 sq.in.)
Moment of inertia	72.39	68.7
Fishing angle, top	14°	18°
Fishing angle, base	14°	14°

Sections of the two rails and their comparative dimensions and proportions are given herewith. It will be seen that they represent distinct types of design.

Public-Service Engineers on New York Subway Accidents

SYNOPSIS—The engineers of the Public Service Commission of New York City report that the Seventh Ave. collapse of Sept. 22 was caused by a blast in the northeast corner of the excavation. E. S. Davis and H. H. Quimby report that the subway timbering has only minor defects, that continuous longitudinal bracing is unnecessary and that the only danger is from rock slides.

Reports have been made on the two recent failures of subway timbering in New York City (Sept. 22 on Seventh Ave. and Sept. 25 on Broadway) by the engineers of the Public Service Commission, which is in charge of building the subways, and by an expert board composed of Edmund S. Davis, Chief Engineer, Boston Transit Commission, and Henry H. Quimby, Chief Engineer, Philadelphia Department of Transit. The latter report deals with both collapses, but the engineers of the Public Service Commission say nothing about the Broadway accident and confine themselves to the earlier one. The chief points in the reports are as follows:

Cause of Seventh Ave. Collapse

John H. Myers, Division Engineer of the Public Service Commission, whose division included the Seventh Ave. section where the collapse occurred, reports that just before 8 a.m., Sept. 22, the bench on the east side of the north heading at 25th St. and Seventh Ave. was being blasted. One hole near the bottom was shot and then four holes in the bench. The collapse followed immediately after the second blast. The rock, while quite hard, appeared to have a number of seams, and marks at the holes indicated that the rock probably broke out more readily than normal, and may have been thrown a considerable distance back from its original position. Large pieces of rock were found near the wreckage of the tower supporting the middle runner beam (see sketch of timbering, Fig. 5, *Engineering News*, Sept. 30, p. 664). They were probably some of the pieces blown out by the blast.

The eastern one of the three runner beams had been forced south, carrying with it two transverse I-beams (20 in.) suspended from it. Most of the easterly transverse I-beams which divided the street timbering into two stories were found lying in a general southeast-northwest direction. Mr. Myers states:

> I formed the opinion that the blast had been the cause of the accident and that its force had caused the members forming the support of the street and trolley tracks to move to the south, and that this southerly movement was especially evident on the east side of the cut, which was the side on which the blast was fired. I also felt that this movement had in all probability been augmented by the fact that the trolley track, having had the supports taken away from beneath it, had hung in a manner similar to a rope, and that this action by either pulling the posts which were above the cross I-beams to the north or else pushing them to the south had in turn augmented the movement which I believe the blast initiated, and when this disturbance of the track reached the point where the surface car was, its weight added to that of the track increased the force tending to move the supporting structure southward. The car being a northbound one was on the east track, upon which side of the cut there is most evidence of this movement. The posts supporting the cross I-beams fell with tops to the south and bottom ends to the north.

Marks on the web of the most northerly transverse I-beam appear to show the point where a flying piece of rock hit this beam and, according to the explanation given by Mr. Myers, started the collapse.

Robert Ridgway, Engineer of Subway Construction, reports: "My study of the matter has led me to the conclusion reached by Mr. Myers, that the initial cause of this accident was a blast which was fired in the northeast corner of the excavation."

He further states that immediately after the accident he instructed the division engineers throughout the subway work to have a thorough inspection of all shoring and street supports of the subway excavation made at once and take steps to remedy any unsatisfactory conditions, all of which instructions were promptly followed.

Chief Engineer Craven's Opinion

Alfred Craven, Chief Engineer, says: "I am of the opinion that the blast which immediately preceded it, and which I believe acted abnormally, was the direct cause of the collapse of the street decking." However, he also considers that the street-railway track structure played a part in furthering the collapse. This structure (composed of yokes, conductor-rail conduit, conductor rails, track rails and concrete encasement) was very heavy and had considerable tensile strength available for suspension-rope action. When it tore apart, after taking a considerable sag, it exerted an unusual strain on the timbering. Concerning the strength developed by this structure, Mr. Craven says: "The track conditions of the underground trolley exhibited unusual strength under longitudinal strain." And he says that had it not been for the track he believes the timbering "would have withstood the shock of the blast and would not have collapsed."

Mr. Craven reports that the tower-and-runner-beam method of supporting the roof at the headings is generally in vogue and has been deemed safe and adequate. Since the accident showed further safeguards to be necessary, steps to provide them were taken immediately. Swaybracing has been put in place near the headings.

Davis and Quimby Against Longitudinal Bracing

Henry H. Quimby and Edmund S. Davis report that there is little to criticize in the timbering used in the subway work. Quoting from their report:

> The types of timbering used by the different contractors vary somewhat. With special reference to the method used by the United States Realty and Improvement Co., in whose work the two recent casualties occurred, we found that the sizes of the material used for the various members give ample strength for the loads imposed by the street traffic, and we are of the opinion that while some cases of details of the framing and bracing were found that are not in accord with the best practice, the greatest and only serious menace to the shoring and to public safety consists in the possibility of rock slides. . . .
>
> The cases wherein details of the timbering have appeared to us as unsatisfactory are the omission of efficient lateral stays at some joints in the posting, points where needles or cross-beams rest upon posts and carry upper-story posts without struts to stay the points against lateral movement, or where no lateral stiffness has been given by the use of fish-plates or cleats to stay the points against buckling, some

cantilever beams carrying upper-story work without struts at buckling points, and the omission of posts under rangers.

The omission of longitudinal struts at or near the posts of the timbering is not general, the instances of the omission being probably oversights on the part of the workmen, or possibly due to removal either by intention or by accident. Such points in the construction should be the subject of repeated inspection, and the whole structure should be continually maintained in a state of completeness and tightness.

Longitudinal diagonal bracing is probably never needed except in the event of the accidental destruction of one or more of the bents, and as it is necessary to remove it before the permanent steel framework of the subway can be erected, it would seem that a continuous system of longitudinal diagonal bracing is scarcely justified. If a considerable stretch with many bents must be maintained between the permanent subway construction and the heading, the distance might be divided into braced portions to be determined according to the local conditions—say by using diagonal braces at intervals of 30 to 50 ft.—and such diagonal braces might better consist of heavy timbers extending from the needle beams to the floor, so detailed that they can easily be shifted as the permanent construction is advanced.

The lesson of the extensive collapse in Seventh Ave., where the blast that caused the disaster perhaps directly destroyed only the nearest bents, would logically be that, as provision against the occurrence of an accident of any sort that may destroy one portion of the timbering, some diagonal bracing should be provided at such intervals as may be justified by the local conditions. If the permanent subway construction should be kept as close to the heading as is practicable and prudent, considering its liability to injury by blasts, manifestly very little of such longitudinal diagonal bracing will be needed.

Rock Slides Are the Chief Danger

Concerning rock slides, however, these experts are very apprehensive. Under conditions such as prevailed in the Broadway excavation at 38th St., where the second collapse occurred, they think it is highly important that adequate supports be provided for all loose rock by putting in rakers or horizontal shoring or by doweling into the solid rock, wherever the condition of the rock indicates liability of a stratum to separation from its bed. They say:

Much of the rock in the excavations is of a nature that makes it subject to loosening in the seams when exposed to weather, temperature changes and vibrations, and the determination of liability to slide is often difficult. At such points, if any doubt exists as to the necessity for shoring, the doubt should be resolved on the side of safety and no chance should be taken. . . . An efficient system of supporting, strutting and wedging should be at once adopted and installed throughout every area in which the strata are tilted at an angle that will subject them to either sliding or toppling.

The character of most of the rock that came under our observation in the excavations is such that its stability when trenched cannot be certainly determined; and especially when its exposure to weather and to the vibration of street traffic is to be continued over considerable time, as is said to have been the case in the Broadway cut at 38th St., prudence would dictate that complete rigid shoring be provided to secure it.

With regard to both the danger of disintegration of rock and the danger of loosening of the timber falsework, these experts recommend that the permanent subway construction should follow closely upon the excavation, so that as little falsework as possible should stand between heading and permanent structure.

Recommendations of Davis and Quimby

They recommend four specific items:

1. That throughout the present construction at every point where the trench is in a rock with inclined strata showing open seams or other evidence of actual or threatened disintegration, the sides be shored across the trench so as to form a continuous strut from side to side of the trench, with additional supports in the shape of raker braces if projecting portions of rock afford the necessary hold.

2. That an effort be made to systematize the work so that the sequence of operations will carry the work of excavation and the erection and concreting of the permanent subway structure close together, so as to require as little falsework and temporary decking of the street as possible.

3. That in future work preference be given to a type of timbering that will provide continuous needlebeams or struts from side to side of the trench, with the joints of the uprights firmly spliced to prevent buckling.

4. That a periodic inspection be made of every point of contact of shoring with the banks, as well as of all connections of members, to insure continuous tightness and prevent deterioration of the timberwork from vibration.

They praise the general conduct of the work and the intelligent forethought and faithful execution of plans. Continuing this excellent practice, and observing also the four precautions recommended, the public will be fully safeguarded against repetition of the accidents, they say, in spite of the element of risk inseparable from the work.

Panama Slide Increases

Unofficial dispatches from the Canal Zone state that the slide in Gaillard Cut which started on Sept. 18 is increasing in seriousness and that now nearly 10,000,000 cu.ft. of earth is in motion over an area of 175 acres. It extends 2,600 ft. along both banks and has an average width of about 1,500 ft. back from the canal center line. No official prediction of the date of opening of the canal has been made, but it is stated that practically all the ships waiting for passage have been ordered to other destinations.

This news is confirmed by the following description of the Culebra or Gaillard Cut slides published in the *Canal Record* for Sept. 15, 1915, just after one of the canal stoppages had been cleared up:

The section of channel affected by the two Culebra slides extends between Sta. 1770 and 1798, a distance of 2800 ft. The east slide lies directly to the north of Gold Hill, and the west slide to the north of Contractor's Hill. The width between the outer limits of the breaks on opposite sides of the cut is greatest at Sta. 1787, where it amounts to 2975 ft.

On the east side the break extends back 1525 ft. from the center line of the channel, and the surface at the outer limit of present breaking is 350 ft. above sealevel. On the west side the break runs back 1450 ft. from the center line, and the present edge is at 585 ft. above sea level. The greater part of the movement at this time is from the west side. On July 1, it was estimated that 5,000,000 cu.yd. were in motion on the west bank in this section, and 4,000,000 cu.yd. on the east bank. Since that date about 2,000,000 cu.yd. of spoil has been removed at the bases of the two slides.

In the past month and a half the forces of the Dredging Division have made some remarkable records in excavation. Five hard material dredges have been employed at the bases of the Culebra slides and they and all the accessories serving them have been worked under heavy pressure 24 hr. a day.

During the month of August the excavation at the bases of the Culebra slides amounted to 793,012 cu.yd. In the same month 66,228 cu.yd. was removed from the base of Cucaracha slide, and the seagoing suction dredge Culebra, which ranges the cut between Gamboa and Paraiso to remove silt and keep the channel clean, took out 132,639 cuyd. The total excavation in the cut by seven dredges was 991,879 cu.yd. From September 1 to the morning of September 13, the total excavation from the Culebra slides was 291,082 cu.yd. and the total from the cut was 380,127.

Until it is known how much of the total slide actually threatens the section of the cut, the time required for the clearing of a ship channel in uncertain.

Major-General Goethals, whose resignation as Governor of the Zone was to have taken effect next month, has returned to Panama from the International Engineering Congress at San Francisco and has announced that he would remain at the canal until "its condition would permit his departure," presumably until the slide situation is satisfactory.

News of the Engineering World

Old Wall Used as Coffer-Dam Fails at Louisville

A section of the old wall of the Louisville & Portland Canal, at Louisville, Ky., which is being widened from 85 to 200 ft., failed on the morning of Oct. 5, admitting a rush of water that flooded the new portion of the canal. A hoisting engineer employed by the contractor, the Henry Bickel Co., of Louisville, was drowned. With a companion he was in a flatboat in the canal opposite the destroyed section, when they saw it begin to move. Both jumped for the solid section, and the engineer, missing it, was caught in the suction. Workmen in the cut, warned by distress whistles from a nearby plant where the accident was seen, escaped with a wetting. Investigation was made immediately by Major J. C. Oakes, Corps of Engineers, U. S. A., in charge of the Louisville District.

The wall was built in 1854 and consisted of cut-stone masonry on a ledge of rock, the construction being shown in the accompanying cross-section (Fig. 3). The contractors had channeled a short distance from the back of the wall, leaving the wall itself with a section of the underlying rock as a coffer-dam. A view of the work, with the old canal on the left and the old masonry wall and ledge in the middle, is given in Fig. 1.

A section 500 ft. in length slid along the seam at El. 404.2, a little over 4 ft. from the bottom, and toppled into the cut. Another section of 100 ft. slid along the bottom of the canal a distance of 50 ft. into the cut, but remained upright. Two sand barges that were tied to the wall near the scene of the break were swept through by the rush of the waters and carried against the new canal wall, while a steamboat which was passing was swept against the old wall. The concreting plant inside the cut was pushed aside about 60 ft. and swept off the rails. The condition after the failure is shown in Fig. 2. The location may be tied up to Fig. 1 by noting the power-plant intake on the left, common to the two views.

The excavation had been completed several hundred yards beyond the point of failure and the wall had been

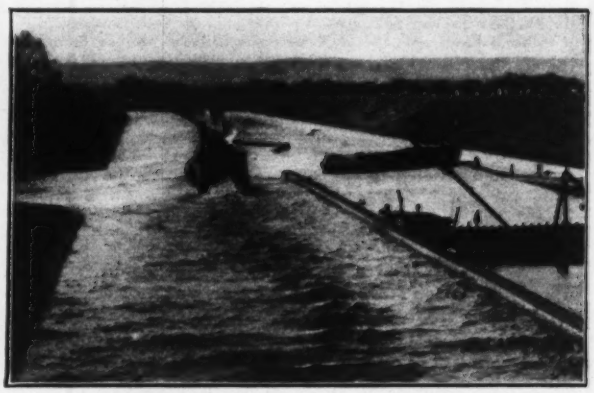


FIG. 2. LOOKING DOWN CANAL TOWARD DESTROYED SECTION OF WALL

standing as it was for several months. The water in the canal had risen about 1 ft. above pool level. It was suggested by a member of the contracting firm that the waves of the passing steamboat had aided in lifting the wall, and by increasing the height of the water added the pressure necessary to move it. Both the Government en-

FIG. 1. WIDENED SECTION OF CANAL BEFORE FAILURE

gineers and the contractor's superintendent, A. G. Butler, had kept a constant watch on the wall and the failure occurred without any previous indication. Butler was on the wall close to the part that failed and was almost caught by the inrush.

The masonry had been reinforced on the excavation side with concrete some time previously. Leaks that had developed had been sealed by applying bags of manure

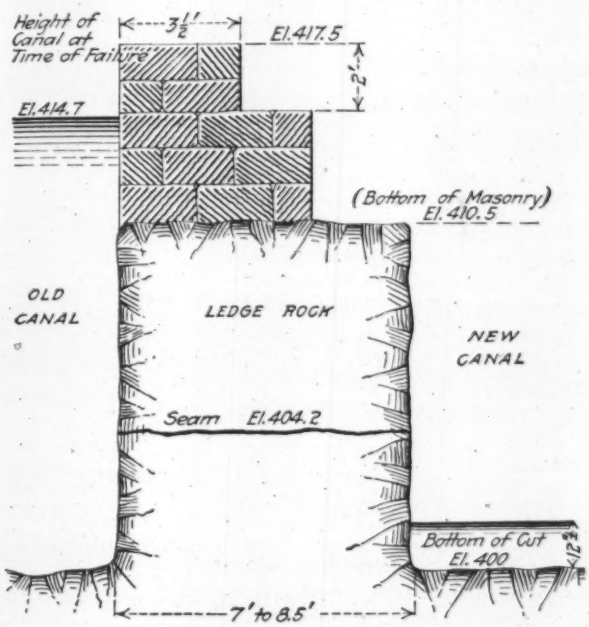


FIG. 3. SECTION THROUGH OLD WALL, LOUISVILLE & PORTLAND CANAL

to them on the canal side and allowing the water to draw them into the holes.

It is probable that the contractor will build a cofferdam beyond the break, permitting the water to remain in the portion already completed. Considerable machinery and trackage were caught, but these can be fished out. The accident is the first that has occurred either in the widening of the canal or the construction of the new locks. A ditch at the lower end of the work will drain a large part of the water after the river falls.

Controlling River des Peres

A 13-mi. river improvement scheme at a cost of $6,000,000 to eliminate flood dangers in the River des Pères valley, St. Louis, has been proposed in a report just made by the Board of Public Service at the request of the Board of Aldermen of that city. The project includes 7 mi. of closed conduits to take the whole of the extreme flood flow and the sanitary sewage of the upper part of that portion of the river within the city and 6 mi. of open storm-water channel to take maximum-flood flows. Beneath this channel there would be a sewer (already built) which would take all the sanitary sewage of the district, the entire dry-weather flow of the river and the storm water from light showers.

The 7 mi. of combined sewer would begin as a single conduit and continue as two and then as three conduits, each 30 ft. in width. The estimated cost of this part of the work is $4,500,000. The lower 6 mi. (open channel) would range from 70 to 100 ft. in width and from 15 to 25 ft. in depth.

The estimated cost of excavating the channel, lining it with masonry and filling the old bed of the river, where property is valuable, is $1,500,000. The existing sewer beneath the proposed open channel cost about $930,000. To complete the system several branch conduits would be required, taking in small streams. The River des Pères drains 16,000 acres within the city and 54,000 outside it in St. Louis County. Serious floods occurred in the valley in March, 1897, October, 1905, both June and July, 1912, March, 1913, and, most serious of all, August, 1915. (For accounts of the last-named see *Engineering News* of Aug. 26 and Oct. 7, 1915.)

Steamship Line Uses Oil Fuel

The Panama-Pacific Line has just announced that oil-fuel will replace coal under the boilers of the twin-screw steamers "Finland" and "Kroonland," now making the 17-day run with passengers and freight between New York, Los Angeles and San Francisco through the Panama Canal. The necessary changes will be made during November and December for installation of mechanical low-pressure oil-burning apparatus (White system). Besides assuring clean decks and eliminating dust, cinders, coaling delays *en route*, etc., the change will allow higher speeds and more continuous high speed. A 40% reduction in fuel bills and a decrease in the fireroom staff from 60 men to 12 are expected.

The "Finland" and "Kroonland" are the largest steamers ever to be equipped in this manner, being 580 ft. long, 60 ft. broad and having a displacement of 22,000 tons. The fuel will be stored in their double bottoms, and this will make available one-third additional cargo capacity, now used for coal bunkering. The same system has worked satisfactorily on the coastwise steamers "Bunker Hill" and "Massachusetts" and in the fleets of the Standard and Texas oil companies.

Structural Damage Slight in New Orleans Storm

The severe windstorms of the past year at Cincinnati, Galveston and New Orleans have all demonstrated that the structure of a well-designed building is safe against the pressure of any wind. In further comment on this observation J. F. Coleman, consulting engineer, of New Orleans, and W. H. P. Creighton, Dean of the College of Engineering at Tulane University, write regarding the Sept. 29 storm at that city when all wind-velocity records were broken:

Mr. Coleman's Comments

Mr. Coleman's comments in part are as follows:

"Practically all of the buildings which collapsed during the storm were light frame structures or very old brick buildings. In the business center of the city the damage consisted principally in broken windows, ripped-off skylights and slate roofs, blown-off chimney tops, and blown-down smokestacks. The tall structural-steel buildings had a very distinct oscillation during the height of the storm, though so far as I know this oscillation was not measured or even estimated. However, it very evidently was not as great as some of the occupants of such buildings

thought, as there is no evidence of cracks in the brick, stone or terra cotta, with which they are faced.

"On the river front the steel wharfsheds suffered to some extent by having the corrugated-iron siding and the wooden sheathing and composition roofing partly stripped off. Some of these sheds appear to have suffered no damage and the only one which collapsed was wrecked as the result of a boat being blown against the wharf on which it rested, so damaging the wharf as to cause wreck of the shed. In the residence districts few houses escaped unscathed, though a number were badly injured.

"In general retrospect it is surprising that the damage was not greatly in excess of what it is. Our modern buildings have been usually designed for wind loads from a 60-mi. velocity, and no doubt in many instances for lesser loads. For 3½ hr. the wind had a velocity in excess of 60 mi. per hour, reaching 86 mi. sustained velocity with one gust of 120 mi. This city contains approximately 75,000 buildings, of which number not much more than 50 were wrecked, and these mostly of the flimsiest frame construction. The casualties within the city were 15 killed and 40 injured."

Professor Creighton's Report

Professor Creighton sends the following information supplementing his report of last week:

"Last week your correspondent declared that no substantial, well-built, modern structure suffered more than trivial damage. After interviewing a number of superintendents, consulting engineers and architects, and after examining a number of wrecked structures, no reason has as yet been discovered for changing that opinion. In the early part of an interview the superintendent or owner would make broad claims for the disabled structure, but ultimately would admit some defect. Incidentally, it must be admitted that it is not necessarily economical to design all buildings to withstand hurricanes.

"The steeple of a prominent church, built in 1857, fell. The mass of wreckage at the foot of this steeple is largely made up of single bricks with no mortar on one side. The failure of the mortar to adhere at all to the brick indicates defective adhesion and probably points to a failure to wet the bricks before laying them. An architect remarked that the mortar on the bricks of overturned house chimneys had evidently deteriorated as it seemed largely composed of sand and that he had noticed no cases where chimneys laid up in cement mortar had fallen.

"New Orleans has now an unexcelled water filtration plant. During the storm the water pressure dropped only 5 lb., although several mains of 8 in. or so were completely broken and caused a great leakage. Formerly, however, people depended upon conducting the rain which fell on the roofs into cisterns made of cypress. This has resulted in the city of New Orleans having more slate roofs than any other city. Slates sweat a little in the early morning before the sun is high and this rusts the iron nail that holds them on the roof. When the head of the nail is rusted badly it requires but little wind to blow the slate away. Fancy tiles should be fastened, preferably by copper fastenings, to the roof or ridge pole. Similarly slates and shingles would be more permanent if fastened with copper fastenings. In this storm a Bedford limestone block about a foot square and three feet long was pushed off a part of the facade of a church. The builders evidently thought that its weight ought to be ample to keep it in place.

"The shipping on the river front was not furnished with heavy enough lines. A couple of light 3-in. hawsers are insufficient to hold vessels of any considerable size. Many of the vessels should have been held by 6-in. lines.

"All observers noticed the considerable pulsations of the barometer during the storm. The wind came in strong gusts. There seems to be no doubt that at times the pressure outside the roof of a building was less than the pressure inside and as a result more or less of the roof would be lifted off. Thus at Tulane University there was a large tank sunk in the ground and covered with boards 3 in. thick, 12 in. wide and 7 or 8 ft. long. The upper surface of these boards was even with the surface of the ground. During the storm the boards were lifted and dropped into the tank. Architects take much care in designing structures against the downward pressure of the air and make little or no provision against the effects of any lifting power it may develop. This cyclone searched out hundreds of open sheds and lifted corrugated-iron roofing and sent it flying, or if the roofs held fast it raised the sheds clear of the ground, and when the sides were well inclined to their proper position, flattened the whole structure."

Wall of Covered Reservoir Slides Out

The clearwater reservoir of the Portsmouth, Ohio, filtration plant was wrecked on Sunday, Oct. 3, by the failure of a 75-ft. length of concrete side wall. The wall at this point was about 30 ft. high and rested on rock of poor quality. The breakout was sudden, although leakage from the embankment outside the wall had been noticed several hours before, and a moist condition of the bank had prevailed for some time previously.

The reservoir is 260 ft. by 260 ft., about 16 ft. deep from floor to roof, with a capacity of about 8 million gallons. The roof is a reinforced-concrete slab on brick piers. The floor is laid directly on the ground (part on fill). The wall is reinforced concrete, 18 in. thick at top, 30 in. thick at floor, and continuing on uniform batter to rock. Buttresses on the water side had their reinforcing tied into longitudinal rods in the wall.

At the point of break the bottom of the wall was about 14 ft. below floor, or 30 ft. below roof, and the reservoir floor was on backfill. The rock contained mud seams, and its surface sloped downhill. The failure appears to have been a sliding on the rock.

Local reports name the J. F. Witmer Co. as engineers for the reservoir. Curtis & Shumway were contractors. Although in use, the reservoir had not been accepted or fully paid for, on account of lack of tightness.

Detroit-Superior Arch Closed—The closing members of the 591-ft. steel arch crossing the Cuyahoga River in the new Detroit-Superior viaduct at Cleveland, Ohio, were placed Oct. 6, 1915. The middle lower chord members of both trusses were placed simultaneously.

A Company of Engineers has been organized in the cadet brigade at the University of Illinois. There will be a captain, two lieutenants and 54 men. The company will receive some infantry drill, such as marching and company movements. There will be also "sand-table" lectures on trench construction and earthwork and possibly topographic surveying and map sketching. It is expected to develop men who would be valuable in the organization of volunteer engineer companies. A similar organization has already been noted in the Cornell University Cadet-Corps.

Cast-Iron Dome for Sale—The old cast-iron dome of the capitol at Madison, Wis., has been taken down to make way for the new dome and is now for sale. The various members were removed in such form as to permit their reërection and are now stored on the university campus at Madison ready for the purchaser. All pieces are marked to fit a specially prepared erection plan to facilitate erection. The total weight of metal is estimated at between 800 and 1,000 tons.

PERSONALS

Mr. J. B. Holtzworth has been appointed Assistant Engineer of the Western Maryland Ry., to succeed J. M. Harris, who has entered the employ of the Poole Engineering Co., of Baltimore, Md.

Mr. W. H. Gould, formerly Sanitary Engineer of Lucas County, Ohio, will in the near future open an office in The Nasby, Toledo, where he will engage in the practice of civil and sanitary engineering.

Mr. Joseph Fawcett, formerly Surveyor of Greene County, Ohio, has been appointed County Road Superintendent under the new Cass law, which places the county surveyor at the head of the road department.

Mr. G. H. Hutchinson, well known in the Middle and Far West among contractors, has become associated with the Bucyrus Co., of South Milwaukee, Wis. He will be in charge of its recently opened office at 900 Hibernian Building, Los Angeles, Calif.

Mr. A. C. Watson, Division Engineer of the Logansport division of the Pennsylvania System, has been appointed Division Engineer of the Cleveland & Pittsburgh division. Mr. Watson will fill the vacancy created by the recent death of E. F. McCrea.

Mr. F. W. Brown, formerly Superintendent of the Louisville division of the Southern Ry., has been promoted to the position of Assistant to the General Manager, with headquarters at Washington, D. C. He will have general charge of train tonnage and efficiency.

Mr. Louis A. Boulay, formerly associated with the firm of the Smith & Boulay Co., Consulting Engineers, of Toledo, Ohio, and now of the recently organized firm of L. A. Boulay Co., Civil and Sanitary Engineers, 1248 Nicholas Building, Toledo, has been appointed Sanitary Engineer of Lucas County, to succeed W. H. Gould.

Mr. Arthur C. Eversham, M. Am. Soc. C. E., formerly Assistant Chief Engineer of the Kansas City Terminal Ry., is now associated with the Kansas City Bridge Co. as Engineer of Construction. He will have entire charge of the construction work of the company and will give special attention to government and railroad construction.

Sir William H. Lindley, City Engineer of Frankfort, Germany, from 1884 to 1896, and engineer for water-works and sewerage improvements in that and many other German cities, has been honored with the degree of Doctor of Engineering by the Technical High School of Darmstadt, Germany. His father, William Lindley, designed the sewerage system of Hamburg after the great fire, which was the first modern sewerage system in Germany.

Messrs. C. H. Vaughan, M. Am. Soc. C. E., formerly Second Vice-President and Chief Engineer of the Penn Bridge Co., Beaver Falls, Penn., and H. R. Hortenstine, M. Am. Soc. C. E., formerly Contracting Manager of the same company and J. O. Childers, formerly with the erection department of the McClintic-Marshall Construction Co., and in charge of the erection of the lock gates at Panama, have purchased the plant of the York Bridge Co., of York, Penn., which will be incorporated under the name of the York Bridge and Construction Co.

OBITUARY

Axel Samuel Berquist, M. Am. Soc. C. E., inventor and patentee of the suspension bunker which bears his name, died at his home in Brooklyn, N. Y., on Oct. 6, after a long illness.

William M. Whelan, Superintendent of the Elizabethtown Water Co., of Elizabeth, N. J., died on Oct. 3 at the home of his sister in that city, at 58 years of age. Mr. Whelan had been in the employ of the water company since boyhood.

L. A. Fowler, head of the contracting firm of L. A. Fowler & Son, died recently at his home in Kansas City, Mo. This firm has done a large amount of building work in Kansas City. One of its larger contracts was for the annex to the Baltimore Hotel in that city.

Arthur S. Mann, M. Am. Soc. M. E., Mechanical Engineer of the General Electric Co., of Schenectady, N. Y., and formerly lecturer at Columbia University, died at Saranac, N. Y., on Oct. 3, at 45 years of age. He was born at Medbury, Mass. Mr. Mann was an authority on steam generation. At various times he also was associated with the Allis-Chalmers Co. and the Metropolitan Street Ry. Co., of New York City.

Gustave C. Kuhlman, founder and former President of the G. C. Kuhlman Car Co., died on Oct. 4 at his home in Cleveland, Ohio. He had been in ill health for some time and had recently suffered a nervous breakdown. Mr. Kuhlman was one of the pioneers in the street-car building industry in the Middle West. In 1881 he organized the company which still bears his name and opened a shop on St. Clair Ave., Cleveland, where he built horse-drawn and cable cars. When electricity was introduced for street-car systems the plant was expanded and moved to the Broadway car barns at Aetna Road. In 1903 Mr. Kuhlman sold his holdings in the company to the J. G. Brill Co., of Philadelphia, at which time the Kuhlman Co. was reorganized. Since his retirement from the company Mr. Kuhlman had been northern representative of the Martindale Mercantile Agency. He was 56 years of age.

ENGINEERING SOCIETIES

COMING MEETINGS

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION.
Oct. 19-21. Annual meeting, at Detroit, Mich. Secretary, C. A. Lichty, 319 N. Waller Ave., Chicago.

ASSOCIATION OF RAILWAY ELECTRICAL ENGINEERS.
Oct. 18-24. Annual meeting in Chicago. Secretary, J. A. Andrencetti, C. & N. W. Ry., Chicago, Ill.

MAINTENANCE OF WAY AND MASTER PAINTERS' ASSOCIATION.
Oct. 19-21. Annual meeting in St. Louis. Secretary, T. I. Goodwin, C. R. I. & P. R.R., Eldon, Mo.

NATIONAL MUNICIPAL LEAGUE.
Nov. 17-19. Annual meeting in Dayton, Ohio. Secretary, C. R. Woodruff, North American Bldg., Philadelphia, Penn.

Southwestern Electrical and Gas Association—The 12th Annual Convention will be held at Galveston, Tex., May 17-20, 1916. H. S. Cooper, the secretary, recently made a trip to Galveston to see whether the storm had rendered it inadvisable to hold the convention there. He states that he found the business of the city almost normal and that there is no reason for changing the place of meeting.

American Institute of Chemical Engineers—The winter meeting will be held in Baltimore, Md., Jan. 12-15. The date selected is later than usual owing to the summer meeting having been held late in August in San Francisco. As the attendance of Eastern members at the San Francisco meeting was small, it is hoped that they will turn out strongly for the Baltimore meeting. The secretary is J. C. Olsen, Cooper Union, New York City.

National Lumber Manufacturers' Association—A series of meetings has been planned by the trade extension department of the National Lumber Manufacturers' Association, which is designed to teach the general public the advantages and general availabilities of wood as a building material. The first of these meetings was held on Sept. 23 in the rooms of the Commerce Club, Toledo, Ohio. The secretary of the association is R. S. Kellogg; the manager is E. A. Sterling, 925 Lumber Exchange, 11 South La Salle St., St. Louis, Mo.

Philadelphia Association of Members of the American Society of Civil Engineers—The annual meeting of the Philadelphia Association was held at the Engineers' Club, of Philadelphia, on Oct. 4. Dr. John A. Brashear, president of the American Society of Mechanical Engineers, delivered an illustrated lecture on "Contributions of Photography to our Knowledge of the Stellar Universe." The officers elected were: President, Edward B. Temple; vice-presidents, Edgar Marburg and John Sterling Deans; directors, J. W. Ledoux, Henry H. Quimby, H. S. Smith and George A. Zinn; treasurer, S. M. Swaab; secretary, W. L. Stevenson.

International Gas Congress—A congress representing the American gas industry was held at San Francisco from Sept. 27 to Oct. 2. The formal sessions opened with the presidential address of A. C. Humphreys, in which he pointed out that public utilities have to face a condition of over-regulation by public authorities. He believed that all should be active to

correct the misleading statements constantly being made. While admitting occasional faults, he claimed that generally the gas business is carried on with due respect to the rights of the public. The first technical paper, by O. B. Evans, was a historical review of the development of water gas. A. G. Glasgow followed with a paper on deep fuel combustion in water-gas manufacture. R. S. McBride, of the United States Bureau of Standards, then presented a paper on the substitution of heating value for candlepower as a criterion of gas quality. Many state and city authorities have already acted to establish the heating-value standard. In the discussion it was suggested that 600 B.t.u. per cu.ft. would probably be generally accepted as the standard. On the second day the congress met in two sections. One considered half a dozen papers on gas for illumination; the other took up nine papers on commercial aspects of the gas business. The discussion in both sections turned largely on the competition between electricity and gas for illumination purposes. The majority of those present represented companies supplying gas alone, and they declared that gas could hold its own in competition with electricity. In order to hold their business in the face of low electric rates the gas companies have engaged in a systematic campaign with both owners and architects, even in some cases furnishing free labor for installing the gas pipes. On the third day a review of modern coal-gas processes was given by the Society of Gas Engineering of New York. A general movement was noted in the East to substitute coal gas for water gas on account of the increase in the price of oil and the uncertainty regarding the future supply.

Appliances and Materials

Flow Meter for V-Notch Weirs

A flow recorder to be used in connection with small V-notch weirs has been designed by the engineers of the Harrison Safety Boiler Works and will be used particularly for measuring-type boiler-feed water heaters. There is a float which moves with each change of head on the weir and in turn rotates a spiral cam (laid out according to the law of the weir, $CH^{\frac{5}{2}} = Q$) through a multiplying gear. The cam moves a pen carriage which records on a paper drum the quantities corresponding to each position of the float. Back-lash has been eliminated by the use of a cable drum instead of a gear and pinion, while friction has been reduced as much as possible by mounting the spindle of the cam upon antifriction rollers. The pen carriage is provided with large rollers or wheels which rest upon horizontal ways, so that the cam follower which is attached to the pen carriage moves diametrically to the cam disk. The pen is suspended from the pen carriage so that it rests lightly against the chart drum and can readily be removed for cleaning or renewing the chart. An integrating attachment consists of a counting train, likewise suspended from the pen carriage and driven by a small roller, which rests upon an aluminum clock-driven disk. When the float and cam are at the position corresponding to the zero head, this roller is at the center of the disk, and hence receives no motion from the rotation of the latter. As the pen carriage is moved away from the zero position, the small roller is carried away the same distance from the center of the aluminum disk, and hence is propelled at a rate corresponding to the rate of flow over the weir. The total movement of the counting train will therefore correspond to the total flow. Further, a visible pointer moving along a large scale with open divisions has been added, making it possible to read the rate of flow from a distance.

HARRISON WEIR FLOW RECORDER

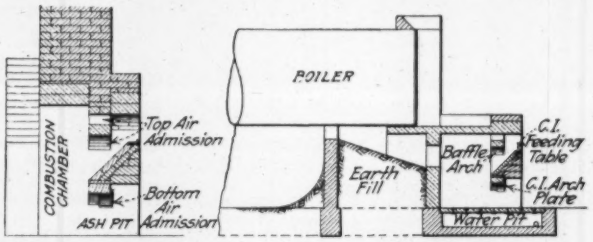
All parts of the mechanism of this recorder are made to accurate dimensions by means of templets and limit gages. To be sure of the accuracy of the instrument it is only necessary to know that it is properly adjusted—that is, when the float is at zero position; in other words, when the level of water upon which it rests is at the zero level of the weir, the cam must be at zero position, the pen on the zero line of the chart and the integrator roller at the center of the aluminum disk.

* * *

Smokeless Firebox for Kilns and Boilers

A radically new design of furnace for clay-products kilns and boilers has been devised by Paul Beer, President of the Grateless Furnace Co., Des Moines, Iowa. The arrangement is shown in the accompanying sketches. A rectangular firebox has a sloping fuel table leading down from a firing hole and having an ignition arch thrown over it. Beneath is an arch and plate spanning the ashpit. The combustion chamber is forward of the coking table and is spanned by a high arch.

The most difficult requirements of clay-products kilns have been satisfactorily met, it is reported by A. W. Clement, Smoke Inspector of Des Moines. During the early firing of a kiln, when low heat is required with great excess of air, the fuel bed fills the space below the bottom of the coking table. The upper portion of the firebox remains open and unobstructed. A little air is supplied through the ashpit. For the second period, which requires an oxidizing heat, coal is piled part way up the coking table. As the fires need cleaning ash and clinker are removed from underneath the coking plate edge and fresh coked fuel falls down to replace it. Volatile matter passes over the incandescent bed of coked fuel below. More air is supplied from the front of the ashpit, which is entirely open and without grate bars. When excess air is required the upper part of the firebox is left partly open. During the high heat for vitrification the fuel bed is carried higher up to close the fire hole and all air is cut off over the fire except that which comes through a small hole in the baffle arch. Air admission through the lower fuel bed is obtained by regulating the cleaning period. A reducing gas can be produced without smoke. A saving of nearly $60 per kiln per heat is reported in the paving-brick plant of the Barbour Asphalt Paving Co. The time of firing was reduced from 11 days 8.7 hr. to 9 days 14.3 hr.



GRATELESS GRAVITY-FEED KILN AND BOILER FURNACE

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., OCTOBER 1, 1915.

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C. W. DIBBLE, Vice-President,
HILL PUBLISHING COMPANY.

Sworn to and subscribed before me this 30th day of September, 1915.

RICHARD L. MURPHY,
Notary Public.
(My commission expires March 30, 1917.)

Engineering News

VOLUME 74 OCTOBER 21, 1915 NUMBER 17

Ornamental Bridge at Akron Built of Slag Concrete

A highway and interurban railway bridge of rather striking appearance has been completed during the past summer across the gorge of the Cuyahoga River on the line of North Howard St. extension in Akron, Ohio. In addition to its extreme height and artistic design the bridge is notable because it was built practically throughout of reinforced concrete using a blast-furnace slag for aggregate.

The bridge is 781 ft. 9 in. long, made up of five main arch spans 127 ft. c. to c. of piers and an approach at each end, of column and girder construction. It is 190 ft. high from bed of stream to grade, which makes it one of the highest—if not the highest—concrete highway viaducts on record, although the Tunkhannock viaduct now nearing completion for the Delaware, Lackawanna & Western R.R. exceeds it in height by about 50 ft. The bridge carries a 26-ft. roadway, with provision for a single line of interurban railway and two bracketed sidewalks each 4 ft. wide.

NORTH HOWARD ST. BRIDGE ACROSS CUYAHOGA RIVER, AKRON, OHIO

In design all of the arches are alike. Each consists of two reinforced-concrete arch ribs, 4 ft. deep at the crown and 3 ft. wide throughout, carrying the girders and slab of the floor on spandrel columns crossbraced transversely near the springing line of the arch. The ribs are also transversely braced at every other column. Expansion joints are provided at the side of each pier, the longitudinal girders (which are in line with the arch ribs) resting upon brackets and the floor slab resting on a shelf on the beams at each joint.

The approaches are of the same construction as that part of the arches above the ribs, the columns resting on rock instead of on the ribs. They carry the roadway from the abutment of the last arch to the crest of the hill.

The piers, which are founded on solid rock only a short distance below surface, are of hollow box section, 14x23 ft. in outside plan, with longitudinal outside walls 3 ft. thick and transverse outside walls 16 in. thick. These walls are reinforced against bending and are further crossbraced by horizontal diaphragms every 30 or 40 ft. Above the coping the piers are continued up only as walls in line with the arch ribs.

Some gravel concrete was used in the piers, but the bulk of the concrete was made from crushed slag from the Corrigan-McKinney furnace at Cleveland, Ohio, and a sand taken from the site of the bridge. Approximately

FIG. 1. TRAIN ON THE OVERFAIR RAILWAY, PANAMA-PACIFIC EXPOSITION

5,000 cu.yd. of concrete and 180 tons of steel were used in the construction. The roadway is paved with wood block, the cost of which will be partly defrayed by the state, in accordance with the law that provides state aid for main market roads.

The main construction was carried on by a cableway across the valley. The arch centers were framed steel arches, spanning from the copings of the piers. On account of the great depth of the gorge this type of centering was about the only one which could be used.

The bridge was designed by Wilbur J. Watson & Co., Bridge Engineers, Cleveland, Ohio, under the approval of E. W. Paul, County Engineer, Summit County, and was built by the MacArthur Bros. Co., of New York City. George L. Ehrman was the Resident Engineer, representing the county and the consulting engineers.

Carrying the Panama-Pacific Exposition Visitors

Transportation facilities around the grounds of the Panama-Pacific Exposition at San Francisco, Calif., are furnished by a miniature railway and trackless automobile trains operating on the roadways.

The Overfair Ry. is a double-track line 7 mi. long. It is of 19-in. gage, with 20-lb. rails laid on sawed spruce ties in rock ballast, except that along the water front the track is laid upon the sand beach. Timber trestling aggregating nearly 1,000 ft. in length is used at one point to carry the line above the level of high tide. The maximum grades are 2½%, and the sharpest curves are of about 120-ft. radius. One of the trains is shown in Fig. 1.

There are numerous grade crossings with the standard-gage tracks of the exposition terminal system, and at the various roadway crossings the rails are laid flush with the surface. The switches, frogs and crossovers are of standard types in miniature. At three terminals there are turntables of steel-girder construction revolving on center castings and operated by hand. Another terminal has a Y-track for reversing the trains. Numerous stopping points, with platforms, are provided along the line. The yards and roundhouse are located at the Fort Point terminal.

The equipment consists of four steam locomotives, one six-wheel tank engine for switching, 65 passenger and 10 freight cars. During construction a work train was used, consisting of the six-wheel engine and 10 flat cars 14 ft. long. The passenger trains have 6 to 12 cars and run at an average speed of 15 mi. per hr.

The passenger locomotives are of the 4:6:2 type, 5½ ft. high from rail to top of stack and 25 ft. long overall, with a weight of 29,000 lb. The cylinders are 8x9 in., and the driving wheels are 26 in. diameter, with a rigid wheelbase of 4 ft. 10 in. The boiler has 430 sq.ft. of heating surface (tubes and firebox) and carries 200 lb. pressure. The tender is 8 ft. long, carrying a supply of anthracite and 375 gal. of water. A Walschaerts valve gear is used. The air-brakes and couplers are of special design. The cab is made disproportionately large, in order to accommodate the two men. In appearance, as Fig. 1 shows, the locomotives resemble the large passenger engines used in main-line traffic.

The cars are of wood, mounted on low trucks and having fixed cross-seats set back to back, with open sides and a canopy roof. The cars are 22 ft. long and 3½ ft. wide, with capacity for 16 passengers per car. The locomotives and cars were built by L. M. MacDermott, of Oakland, Calif., who also owns and operates the railway.

FIG. 2. AUTOMOBILE TRAIN ON THE ROADWAYS OF THE SAN FRANCISCO EXPOSITION

A more novel means of transportation is that afforded by trackless trains operated on the driveways, each consisting of an automobile and trail cars. This system was invented by R. B. Fageol, of Oakland, Calif., and is operated by the Fadgl Auto Train Co., of San Francisco. One of the trains is shown in Fig. 2.

The automobile, or tractor, is of special design, weighing 6,000 lb. and having 20-in. wheels with solid rubber tires. It carries four passengers. The tractor hauls three trailers, each weighing 1,500 lb. and carrying 20 passengers. These cars have 24-in. wheels and 12-ft. wheelbase. They have side seats back to back, with a passage between for the use of the conductor. At the ends the seats are raised to clear the wheels. The couplings are of special design, causing the trailers to track with the automobile. A shoe brake is operated in connection with the couplings, being lowered to contact with the ground when the couplings are slackened by reduction of speed. The speed limit is 12 mi. per hr.

Slip of Approach Embankment Damages Concrete Bridge

By Arthur T. Clark*

An instructive illustration of progressive damage to a bridge abutment, caused by improper construction of an earth-fill approach, was recently noted at Herkimer, N. Y.

A 400-ft. four-span reinforced-concrete bridge was completed last spring over West Canada Creek, carrying a 25-ft. roadway and a 5-ft. sidewalk on a 4% grade. The east end, where the trouble occurred, is about 35 ft. above the creek bed. Here the bridge is approached by an earth-

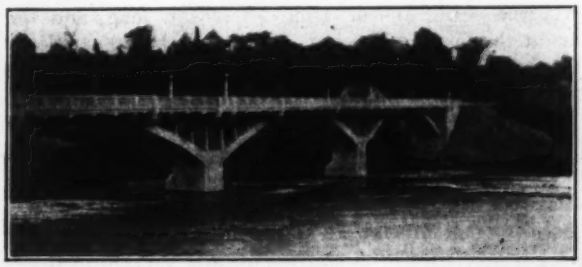

FIG. 1. BRIDGE AND APPROACH WHICH SLIPPED, HERKIMER, N. Y.

fill, built separately from the bridge and under a different contract. The fill is about 160 ft. long, and the deepest part, just outside the abutment, was 25 ft. The embankment was constructed early in the spring, of material taken from a near-by blue-clay bank. Most of the clay was saturated and plastic, and part of it was frozen. A certain amount, estimated at one load in 20, was in a fluid condition. Holes were provided in the sidewalls of the abutment, but placing nearly impervious material adjacent to them prevented effective drainage.

About the middle of June the finished road surface and the south side of the embankment sloughed off on a curved line, as shown in Fig. 2. The toe of the embankment slipped out about 50 ft., and the subsidence carried the guard rail on the bridge with it to the position indicated by the dotted line. The vertical settlement of the edge of the crown of the embankment was about 20 ft. In addition to this damage, the east end of the south sidewall of the east abutment moved out 4 or 5 in., leaving an open crack at the intersection of the sidewall and cross-wall of the abutment.

When the settlement took place work was immediately started refilling with gravel, but for a few days the embankment continued to slip under the added load of material, so that little headway was made. The slipping finally ceased, and the embankment was restored to its

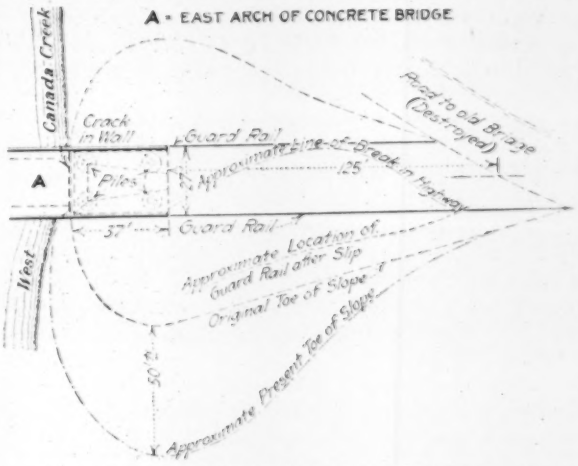

FIG. 2. DIAGRAM OF EMBANKMENT SLIP AT HERKIMER BRIDGE

original grade. To prevent further injury to the sidewalls, ten 1½-in. tie-rods with turnbuckles were placed across the roadway at 3-ft. and 6-ft. depths.

About Aug. 1 the whole south sidewall of the east abutment tipped out about 5 in. The foundation under the easterly arch abutment consists of a horizontal reinforced-concrete wedge 27 ft. wide and 37 ft. in length, extending into blue-clay soil, which forms the bank and bed of the

FIG. 3. CRACKS IN PARAPET OF EAST ABUTMENT

creek. Four large concrete piles had been sunk below this wedge. Tests showed the clay in the base of the embankment so wet that a crowbar could be sunk into it several feet at a single thrust.

*Assistant Engineer with Robert E. Horton, Consulting Hydraulic Engineer, 57 N. Pine Ave., Albany, N. Y.

Of the World's Petroleum Production in 1914, amounting to 400,000,000 bbl. of 42 gal., two-thirds was produced in the United States. The statistics collected by J. D. Northrop, of the Geological Survey, show a production in the United States last year of 265,762,000 bbl. Russia is the next largest producer, with 67,000,000 bbl. to its credit, and then comes Mexico, with 21,000,000 bbl.; Roumania, with 13,000,000 bbl., and the Dutch East Indies, with 13,000,000 bbl.

Novel Bulkhead for Wharves at Jacksonville

By H. D. Mendenhall*

SYNOPSIS—Privately owned deep-water terminal on St. Johns River, at Jacksonville, Fla., has quay wall in which bulkhead is a tight concrete wall cast against continuous sheetpiling backing on vertical I-beams. Fill is relieved by a platform resting on timber piles.

The development as deep-water terminals of the area known as Commodore Point, on the St. Johns River, at Jacksonville, Fla., was finally placed on a fixed footing when on Aug. 2, 1915, permits were received from the United States Government to proceed with construction on the lines requested in the petition from the owners. This permit marks the culminating point of a long period of delays and contentions extending over several years. The property in question was the object of animated political controversies for a considerable time, during which it was proposed as the site for the municipal docks. This controversy waged hot and heavy during several seasons, at the end of which a site some miles down the river was chosen.

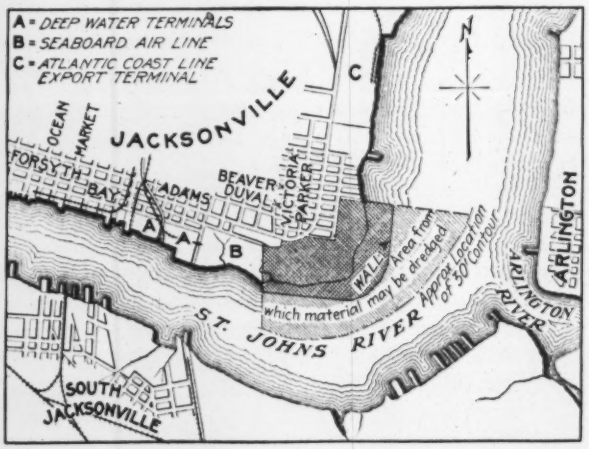

FIG. 1. LOCATION OF NEW COMMODORE POINT WHARVES, AT JACKSONVILLE, FLA.

One reason for rejecting the site in question was the supposed existence of a prohibitive amount of rock that would have to be excavated to render the point available for dock purposes. The owners had reasons to believe that conditions were not really in as bad shape as the committees reported, and early in 1914 the writer was called in to make a thorough examination to discover actual conditions. After the owners' examination had been completed it was found that while there had been no deliberate misrepresentations made as to the amount of rock present, the data from which the estimates had been made were so meager that accurate conclusions could not be reached and erroneous deductions had been made. However, in the meantime the city had resolved to purchase the other site, so the owners determined to develop the property with private capital.

*Consulting Engineer, Lakeland, Fla.

Then came a period of adjusting and readjusting of proposed lines, petitioning and repetitioning to the Government for permits, until finally, after approximately two weeks more than one year from the time the first application had been presented the permits were granted and work permitted to proceed.

Location of Wharf Site

The site, in its relation to the center of the City of Jacksonville, is shown in Fig. 1. The foot of Market St. is approximately the center of the shipping district, and it will be noted that the west edge of the property is about 1¼ mi. east of that point. The property occupies the point made by the right-angle turn of the river and, as finally developed, will cover about 132 acres. Of this area about 75 acres is on the land and 57 in the shallow water adjacent. The land area is a low marsh about 3 ft. above mean low tide at the highest point, but mostly subject to overflow under ordinary tides. The river section will be in water varying from 5 to 20 ft. in depth, although the 20-ft. part is from only a short distance on the extreme point. The river at this point is something over ½ mi. wide, with the channel on the opposite side from the property to be developed.

The river frontage to be developed is 5,182 ft. measured on the outer line. This will be increased as wharf frontage by adding a slip at each end, the one at the west end being 100 ft. wide by 226 ft. long, and the one at the north end being 100 ft. wide by 500 ft. long. The bottom will be dredged to 12 ft. in these slips and to 30 ft. along the main wharf front.

The character of the bottom along the entire face, as determined by a double line 15 ft. apart of wash borings made at 25-ft. intervals on each line, was found to be shell rock for the larger portion of the distance, with a short interval of clay at one point near the west end. Rock is overlain with a stratum of sand varying in thickness from 2 to 40 ft. The rock averages about 30 ft. below mean low tide.

Longitudinal Type of Wharves Proposed

The wharves will be of the longitudinal type, now becoming popular for river improvement where strong currents are encountered. It will be noted from Fig. 1 that they practically parallel the curved axis of the channel. Fig. 2 gives dimensions and bearings in detail. The two main faces, 2,182.3 ft. and 1,500 ft. long respectively, are connected by three short faces of 500 ft. each. This was considered more practical for mooring purposes than to use a continuous curve, and it is contemplated that few vessels more than 500 ft. in length will have to be accommodated for a great many years to come.

It is proposed to dredge immediately to 30 ft. all areas at which rock is found lower than 30 ft. below mean low tide and all the remaining areas to rock only. There will be something over 3,000 ft. of frontage having 30 ft., and for the remaining distance there will be a depth of 24 ft., excepting a few disconnected points that rise to 22 ft. The retaining structure will be designed for an

ultimate depth of 30 ft. so that no additional strengthening will be needed when the deepening is undertaken.

The area behind the wharf front will be filled to 4 ft. above mean low tide with sand dredged from the river bottom. It will require about 1,100,000 cu.yd. of material.

Details of Bulkhead Wall

Figs. 2 and 3 show, respectively, vertical section and plan of the bulkhead to be used to retain the fill. The essential features of this retaining structure will be a concrete and steel vertical wall, anchored back at the

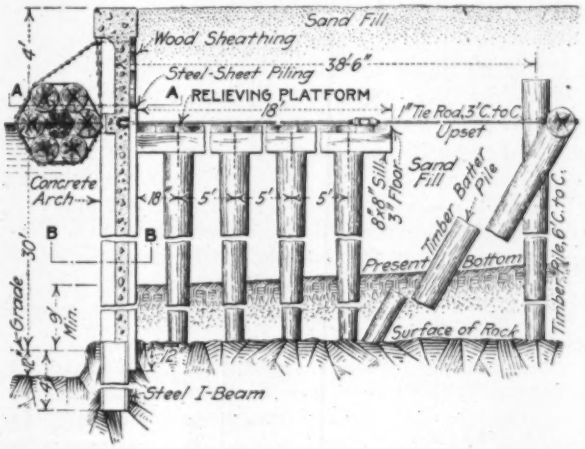

FIG. 2. DETAILS OF CONCRETE AND STEEL BULKHEAD OF NEW JACKSONVILLE WHARVES

water line with rods secured to a braced-pile and deadman system; and a relieving platform of timber piles and flooring to take all load above the water surface.

The design of the concrete-steel wall brings into use a combination of standard steel shapes and concrete that has been little used heretofore for this type of construction. Section *B-B* in Fig. 3 shows the arrangement in its simplest form. It is proposed to drive the 12-in. 31.5-lb. standard I-beams at 3-ft. intervals to a depth of not less than 34 ft. below mean low tide when rock is encountered above the 30-ft. grade, and to a penetration of not less than 3 ft. into rock when rock is found below 30 ft. Tops of I-beams will be left at 3 ft. above mean low tide. Where no rock is to be found, a row of timber piles will be driven along the toe of the wall to prevent its being pushed out by the earth fill. Tops of these timber piles will be left at 32 ft. below mean low tide. Immediately behind the I-beams and secured with steel clips to the flanges at points of contact will be driven a continuous interlocked row of steel sheetpiling. The drawing shows the adaptability to the Wemlinger corrugated section. The specifications provide that the steel piling used shall be not less than ¼ in. thick and have a section modulus of not less than 4. It shall be driven to a penetration of 12 in. into rock where rock is found, and in no case to a greater depth than 35 ft. Tops shall be left about 12 in. above mean low tide. Where no rock is to be found the row of timber piles already mentioned will hold the toe.

The concrete is to be filled in between the I-beams and steel sheetpiling in arched section, as shown. It is to be placed with a tremie after dredging has been completed and the full strain put on the wall. No restrictions are put on the manner of placing the concrete, but it is assumed that the contractor will spring a form in between the outer flanges of the I-beams, and after the concrete has set, release it in some manner and use it again. Concrete is specified to be mixed in proportions of 1:2:4. It is designed to act solely as a protective coating for the steel, although in reality the arched section possesses a definite strength. This strength will simply be considered as increasing the factor of safety of the wall. By applying it as shown, the only steel exposed to the corrosive action of the salt water will be the outer face of the 5-in. outer flange of the I-beams. This amounts to about 14% of the entire face of steel, but as corrosion will occur only at the thickest part of the beam and the application of a coating of some type of protective paint from time to time will be a comparatively easy matter, it is assumed that this exposure will not materially endanger the life of the structure.

The concrete facing is to be not less than 6 in. thick at the thinnest point. Opposite the horizontal wales this thickness will be increased to 10 in. for a vertical space of 8 in. to provide additional protection to the anchorage.

Above the mean-low-tide line the concrete takes the place of the steel sheetpiling as a retaining wall, and is reinforced at intervals of 3 ft. by the extension of the I-beams.

The wall will be finished off with a 12x18-in. coping cast integrally with the main wall and protected on the outer edge with standard metal curb guards.

The anchor system is made up of two 4-in. 5¼-lb. channels, arranged back to back and separated 1½ in. with sections of gas pipe and secured with ¾-in. bolts.

Each wale combination will be 2 ft. 11 in. long, resting against the inner flange of the I-beams. As already noted, these wales will be completely incased in concrete. The tie-rods will consist of two 1-in. by 20-ft. rods, upset

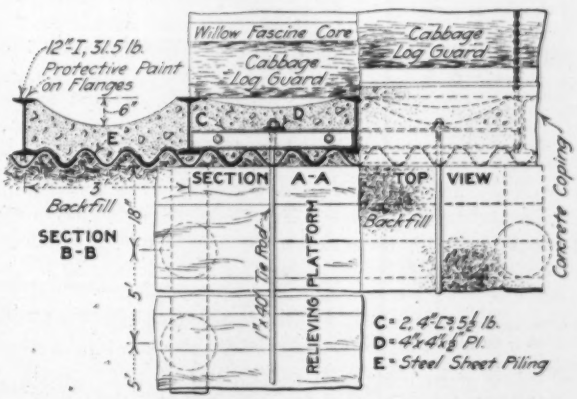

FIG. 3. PLAN AND PLAN SECTION OF BULKHEAD

each end to 1⅜ in. and connected with standard turnbuckles.

Details of Anchor-Pile Construction

The anchor-pile combination consists of a pile driven vertically to rock every 6 ft. on a line 39 ft. from, and parallel to, reference line of bulkhead. Back of this and bolted to it with 1-in. bolts at water surface will be a horizontal timber deadman averaging 12 in. in diameter. To render the system rigid a batter pile will be driven at intervals of 6 ft. at an angle of 30 deg. with the ver-

tical, and butted against and drifted to the deadman as shown with ¾-in. drift bolts. It is estimated that a possible maximum stress of 49,800 lb. will be put on this batter pile during the period of sand filling.

The relieving platform is constructed of timber piles driven on 5-ft. centers normal to line of bulkhead and 6-ft. centers parallel to this line. The piles are to be driven to rock or clay, and the tops are to be cut off 12

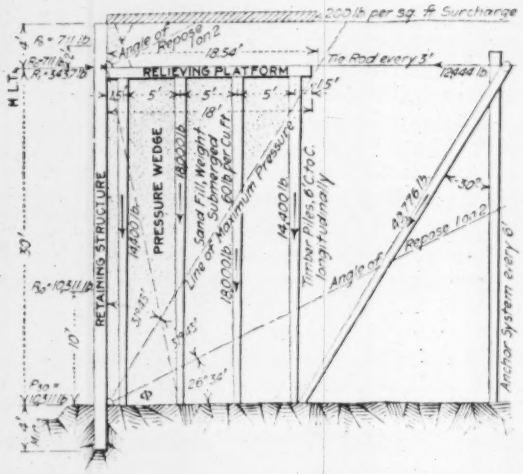

FIG. 4. METHOD OF FIGURING STRESSES IN JACKSONVILLE BULKHEAD WALL.

Rational Formula for total Horizontal Pressure

$$P = (\tfrac{1}{2} wh^2 + vh) \tan^2\left(45° - \frac{\Phi}{2}\right)$$

For Loading Above Relieving Platform

w = 100 lb. per cu.ft. v = 200 lb. per sq.ft. ϕ = 26° 34'. h = 4 ft.

$P_a = (\frac{1}{2} \times 100 \times 4 + 200 \times 4) \times .3819 = 711$ lb. horiz. ft.

For Loading Below Relieving Platform

w = 60 lb. per cu.ft. v = 0. ϕ = 26° 34'. h = 30 ft.

$P_{30} = \frac{1}{2} \times 60 \times 30 \times 30 \times .3819 = 10{,}311$ lb. per horiz. ft.

Center of Pressure = 10 ft. above toe.

Reaction at M.L.T. ($= 0$) $= \dfrac{10{,}311}{3} + 711 = 4{,}148$ lb. per horiz. ft.

For uniformly distributed load, maximum moment is for beam supported both ends

$$M = \frac{1}{8} wl = \frac{10{,}311}{8} \times 30 \times 12 = 463{,}995 \text{ in.-lb. per horiz. ft.}$$

for beam fixed both ends

$$M = \frac{1}{12} wl = \frac{10{,}311}{12} \times 30 \times 12 = 309{,}330 \text{ in.-lb. per horiz. ft.}$$

for compromise of these two

$$M = \frac{1}{10} wl = \frac{10{,}311}{10} \times 30 \times 12 = 371{,}196 \text{ in.-lb. per horiz. ft.}$$

By assuming uniformly increasing load, these values would be increased 2.36%.

Weight on Relieving Platform = 600 lb. per sq.ft.

in. below mean low tide. Drift-bolted to these with ¾-in. drift bolts at each point of support will be 8x8-in. yellow-pine caps. These will be placed normal to the line of the bulkhead, will be 18 ft. long each, and be supported by four piles. The floor will be composed of 3-in. yellow-pine planking, fastened to the cap at not less than two points with wire spikes. The flooring will not be laid permanently until after the sand fill has been placed to the top of the caps, after which it will be permanently fastened and the fill then continued to 4 ft. elevation.

It is assumed that the timbers and steel behind the bulkhead, being thus completely submerged and surrounded with sand, will last practically indefinitely.

Fig. 4 shows the diagram of stresses and the various assumptions on which the design was based. It will be noted that an assumption of 100 lb. per cu.ft. is made for all materials above water, with an additional loading of 200 lb. per sq.ft. on the top of fill. Material below water is assumed to weigh 60 lb. per cu.ft. submerged and have an angle of repose of 1 on 2.

After canvassing all known formulas and experimental data relative to earth pressures, it was finally decided that the only one that was known to be absolutely safe was the old original "rational formula," that has stood the test of time. Accordingly it was used, and the resulting pressure against the wall exerted by the sand fill from the water surface to a depth of 30 ft. was computed to be 10,311 lb. per horizontal foot. The weight to be carried by the relieving platform is 600 lb. per sq.ft. The reaction at the water surface due to the pressures applied at the two-thirds point below the surface and the cantilever action of the wall extending above the relieving platform is computed to be 4,148 lb. per horizontal foot. Placing the rods every 3 ft. subjects them to a theoretical strain of 12,444 lb. each. Each pile of the relieving platform will carry a load of 18,000 lb., and the batter pile, as already stated, will carry a computed strain of 49,796 lb.

In computing maximum moments in the lower section of the wall, it was assumed for simplicity of computation that the load was uniformly distributed and that the two ends were fixed, or acting in cantilever. The considerable factor of safety used is relied on to take care of any possible variation of conditions from these assumptions.

Douglas Fir for Paving Blocks

By O. P. M. Goss*

The following discussion is presented for the purpose of showing recent developments in the use of Douglas fir for creosoted wood-block pavements and to show particularly the steps taken on the Pacific Coast by the West Coast Lumber Manufacturers' Association and by the Association of Creosoting Companies of the Pacific Coast to perfect the treatment of this wood for paving purposes. The objectionable features of wood-block pavements—expansion, bleeding and slipperiness—have been made the subject of considerable study by these associations, and the conclusions arrived at are here given with the hope that they may prove helpful in the fullest development of wood-block pavement.

Measures to Prevent Expansion

Expansion is caused by the absorption of water in the cell walls of the wood. Any treatment that will retard this absorption will assist in the prevention of swelling. Experiments have shown that the thoroughness of creosote-oil penetration plays an important part in retarding volume changes. A block treated with 30 lb. of oil per cu.ft. will, when put to an extreme soaking test, swell practically as much as a similar one thoroughly penetrated but containing only 12 lb. per cu.ft. The former will absorb less moisture in amount than the lat-

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ter, but the swelling action will be practically the same in both.

The main point in treating blocks is to secure a thorough penetration with a reasonable amount of oil. Creosoted Douglas-fir blocks thoroughly penetrated with 18 lb. of oil per cu.ft. reduced to 12 lb. per cu.ft. are relieved of 35% of their tendency to shrink and swell when put to extreme soaking tests.

As an additional safeguard against expansion troubles we recommend attention to the following details: (1) Place blocks on an asphalt- or tar-coated base, for this seals the lower end, almost eliminating the possibility of water entering at the base of the block; (2) provide liberal expansion joints adjacent to the curb; (3) lay blocks in courses at an angle of 60 to 67° to curb, that the expansion may be relieved within a short distance, whether it occurs along the short or the long dimension of the block.

If blocks are laid in courses at right angles to the curb, expansion the long way of the block may be taken up at the curb, but if it occurs along the short dimension, longitudinally of the street, there is no relief except in compression of the blocks or in transverse expansion joints. Such joints are to be avoided when possible, as they are very likely to be a source of trouble.

Prevention of Bleeding Troubles

It is the general practice on the Pacific Coast to use a pure coal-tar oil of 1.03 to 1.07 sp.gr. at 60° F. and to treat the blocks with from 16 to 18 lb. per cu.ft., which amount is afterward reduced by "expansion and vacuum" to 12 lb. per cu.ft. This reduction in oil content is accomplished by heating the blocks while submerged in the preservative from 180° (the pressing temperature) to 230° as rapidly as possible and holding them in the oil bath at this higher temperature for one hour.

The increased heat expands the oil and vapors, and the expansion together with the final vacuum reduces the oil content 4 to 6 lb. per cu.ft. This treatment gives an ideally treated block with a thorough penetration of sufficient oil to preserve it. This block will not bleed under street conditions. A pavement of these blocks was laid in Tacoma, Wash., about three months ago, and it has shown no signs whatever of bleeding during a week of as hot weather as is usually experienced on this coast (about 87° F.).

Slipperiness Least with Douglas Fir

Slipperiness is the least of troubles experienced with Douglas-fir blocks. This wood is not extremely hard, but is strong and tough. Its fibers compact and mat together. The hardness of the wood materially affects the slipperiness of the pavement. The ideal paving wood is one strong enough to resist the wear and not so hard but that fine gravel may be rolled into it to produce a surface resistant to wear and one that is not slippery.

If the joints are filled full of asphalt or tar and expansion and bleeding occur, the filler material will be forced to the surface and will mix with the surplus oil, causing a disagreeable and slippery surface. The surface may be scraped clean and sanded, which will in time solve the difficulty, but such a surface is entirely unnecessary.

Douglas fir is unlike most woods from the standpoint of impregnation. It has been necessary to develop treating methods especially for this wood in order to get the results desired. Paving blocks of any wood should be treated in such a way as not to cause any appreciable loss in strength. The steaming process is not suitable for treating Douglas-fir blocks, since the fiber is injured by this treatment. The following treatment has been developed for paving blocks and has proved thoroughly satisfactory:

> The blocks shall be placed in the treating retort, direct from the saw, and the preservative introduced and heated to approximately 215° F. for from 1 to 4 hr. The preservative shall then be drained off and a vacuum of 23 to 26 in. drawn to take out the surplus vapors, etc., from the wood cells. The vacuum shall then be broken by the introduction again of the preservative, which is then pressed into the wood at a temperature of 180° F. until the blocks have received from 16 to 18 lb. per cu.ft. After receiving the required amount of oil the pressure shall be released, and the temperature of the oil gradually raised to 230° F., and held for 1 hr. A final vacuum of 23 to 26 in. shall then be drawn to dry the blocks of the surplus surface oil, leaving a thoroughly impregnated block.

This treatment produces an ideal block, which retains its original strength and is amply suited to resist swelling and decay. In no case should Douglas-fir blocks be subjected to a steaming treatment.

Handling Blocks in Paving Work

Blocks should be delivered from the plant directly to the job and close-piled until laid. Close-piling keeps the blocks in the same moist condition as when they are taken from the treatment. They are not thoroughly green, yet they are quite well up to their maximum volume. The amount of swelling that will follow is desirable in that it tightens up the pavement, almost eliminating joints. Blocks properly treated, after swelling to their maximum volume, shrink very slowly. In fact they have almost a constant volume under normal street conditions. This is because the cell walls are wet and thoroughly painted with coal-tar creosote, and moisture is very slow to pass out through the partially waterproofed cells.

Recommended Specifications

Blocks should be cut from sound, strong, close-grained lumber and accurately dressed. Variations in thickness and depth should not exceed $\frac{1}{16}$ in. They should be creosoted in accordance with the method described and should be placed upon a smoothly finished concrete base, painted with pitch or asphalt immediately before blocks are laid. The painting should be thorough and a bond secured betweeen the paint coat and the concrete.

Blocks should be laid in courses at an angle of 60 to 67° with the curb and with as close joints as possible. The lower portion of the joints should then be filled with asphalt or pitch sufficiently fluxed to enable it to flow into the joints. The upper portion of the joints should be filled with hot dry sand and the entire surface rolled with a 10- to 14-ton steam roller to seat the blocks thoroughly and to fill the joints completely.

Liberal expansion joints should be provided along each curb. The lower half of the expansion joints should be filled with bituminous filler and the upper half with clay. Fine gravel ¼ to ½ in. in diameter should then be scattered over the surface and rolled into the blocks until a surface satisfactory to the engineer is secured.

A coat of fine sand should be spread over the surface of the pavement and left for 30 days after the street is opened to traffic. Additional fine-gravel coatings may be spread on the surface from time to time if desirable.

Provisions for Expansion of Blocks

It is very important to provide liberally for expansion. From the following data it is possible to arrive at the proper width of expansion joint for any width of street. On the average each joint between blocks may be counted on to accommodate 0.02 in. expansion. When blocks are treated, handled and laid as described, the following formulas give the proper width of expansion joint along each curb:

When blocks are cut from 4x8-in. lumber, width of expansion joint in inches equals width of street in feet × 0.045. When blocks are cut from 3x6-in. lumber, width of expansion joint in inches equals width of street in feet × 0.04.

The expansion-joint material, to give the best results, should be composed of some high-grade asphaltic cement with 20% by weight of very fine sand stirred in while the pitch is hot. This stiffens up the filler, enables it to remain in place in warm weather and also reduces the cost slightly.

The joint filler should be a good quality of D-grade asphalt or similar material fluxed sufficiently to allow it to be worked into the joints.

The pitch or asphalt used to coat the base should be as stiff as possible, consistent with getting a good bond on the smooth concrete base. One way to secure a bond on the concrete when using a heavy pitch-paint coat is to thoroughly clean and spray the base very lightly with some light oil just before the hot pitch is applied.

Small Mechanical-Filter Plant, Franklin Furnace, N. J.

By R. H. Eurich*

SYNOPSIS—Design and operating results of a small mechanical filtration plant designed to require a minimum of attendance with a view to reducing the cost of operation. This has been attained by providing liberal coagulating capacity, large filter area and very simple control apparatus.

In the fall of 1913 the New Jersey Zinc Co. undertook the construction of a mechanical filtration plant for Franklin, N. J. The population of Franklin is estimated at 2,200 and the takers of water from the distribution system as 1,200. The source of supply is Franklin Pond, area 44 acres, situated in the southern part of the borough. The pond is fed by the Walkill River and Black Brook; the combined catchment area is 31 sq.mi. of steep forested hills, mountain-top swamps, and, in the valley, rolling agricultural land. The water is subject to sudden fluctuations in color and turbidity, the color ranging from 20 to 100 and the turbidity from 10 to 60.

The filtration plant was designed for a normal capacity of 100,000 gal. per day, and a maximum of 150,000 gal. per day. Ever since the plant was put in service it has been supplying 130,000 to 140,000 gal. per day.

The filter plant is on the east bank of the Walkill River about 200 ft. below the dam at the outlet from Franklin Pond. The structures (see plan and section, Fig. 1) are an intake in the narrows of the pond, a coagulating reservoir, regulator house and filters, and a pure-water reservoir. The water flows by gravity from the pond through the intermediate structures to the pure-water reservoir, from which electric automatically operated centrifugal pumps lift the water to a 110,000-gal. standpipe. There is a booster pump for use in case of fire. The construction work was done by the forces of the New Jersey Zinc Co., under the direction of Hazen, Whipple & Fuller, Consulting Civil Engineers, New York City. The work was begun at the end of October, 1913, and the filters were put into service early in May, 1914.

Details of the Coagulating Reservoir

The coagulating reservoir is a covered reinforced-concrete structure, divided into three basins by two walls (see Fig. 1). Each of these basins is divided into three square compartments by two perforated concrete baffle walls. At the far end of the center basin is a concrete skimming weir; at the end farthest from the filters of each side basin is a distributing weir; at the other end of each side basin is a skimming weir. Under the floor, along the center line of each of the three basins, is a 6-in. cast-iron drain opening to each of the three square compartments. The flushing of each basin is controlled by a gate valve placed on the drain outside of the basin in the pipe gallery.

Under normal operating conditions the raw water enters the center basin at the end nearest the filters at a point 4 ft. above the bottom, having been previously dosed with aluminum sulphate, and after being deflected and distributed by a plate placed immediately in front of the inlet pipe, flows through the two perforated baffles and over the skimming weir at the far end. Here it divides into two equal parts and passes through the valves, set in the division walls, to the distributing weirs at the far ends of the side basins. After passing over these weirs it flows through the perforated baffles of the side basins to the skimming weirs at the near end, and from these it passes into pipes that convey it to the filters.

There is an auxiliary raw-water inlet in one of the side basins, thus making it possible to bypass any one of the three basins and to empty it for cleaning or inspection.

The design of the perforated concrete baffles is of interest inasmuch as it is believed to be here applied for the first time. The distribution of the vertical velocities has been regulated by a proper arrangement of circular orifices. These have a diameter of ⅞ in. at the throat, and are

*With Hazen, Whipple & Fuller, Consulting Engineers, 30 East 42nd St., New York City.

flared to a diameter of 3 in. at the downstream side of the 6-in. baffle wall. The distribution of these orifices is the same in all of the baffles and is as follows:

Distance from Floor to Row, Ft.	Number of Orifices in Row	Distance from Floor to Row, Ft.	Number of Orifices in Row
1½	1	5½	5
2½	2	6½	6
3½	4	7½	6
4½	5	8½	7

As a result of this arrangement the velocity at any point in a vertical line varies inversely (nearly) as the distance from the point to the water surface.

Access to the six compartments at the far ends of the basins is through rectangular openings in the baffles. These openings are closed by wooden shutters bolted to frames set in the concrete. Each compartment is vented at the middle of the roof.

The nominal period of sedimentation with a flow of 150,000 gal. per day is 7.7 hr. With one basin out of commission the period is 5.1 hr. The reasons for such a liberal time for sedimentation will be taken up under the discussion of the operation of the plant.

Regulator House and the Filters

The regulator house is of reinforced concrete. Within its area are parts of the three basins, the two filter units, the pipe gallery, the wash-water tank and the operating floor, on which are the chemical tanks, feeds and gages.

There are two filter units, each 8x11 ft. in plan, equal to 0.002 acre.

In order to prevent a free passage of water upward along the filter wall, the forms from the bottom up to the sand line were made of corrugated sheet iron. The wash-water troughs are of concrete, were cast separately and erected in place before the filter walls were poured.

The strainer system of each filter consists of twenty 2½-in. wrought-iron pipes 5 ft. long with seven holes ½ in. in diameter, 9½ in. c. to c., drilled along the lower side, capped at their outer ends and screwed into a 10-in. cast-iron main collector partly buried in the concrete of the floor. The clearance between the laterals and floor is 1 in. The wash-water jets are directed vertically downward against the filter floor, an arrangement which breaks up the jets and secures a uniform distribution of velocity in the rising column of wash water without resort to the use of strainers, screens or distributing device other than a layer of gravel.

The filter sand and gravel were obtained from the Cape May Sand Co. There were five grades of gravel, ranging as follows: (1) ½ to 1 in., placed just to cover laterals; (2) ¼ to ½ in., 4-in. layer; (3) $\frac{3}{16}$ to ¼ in., 3-in. layer; (4) $\frac{1}{16}$ to $\frac{3}{16}$ in., 2-in. layer; (5) $\frac{1}{24}$ to ⅛ in., 2-in. layer. The sand had an effective size of 0.32 mm. and a uniformity coefficient of 1.69.

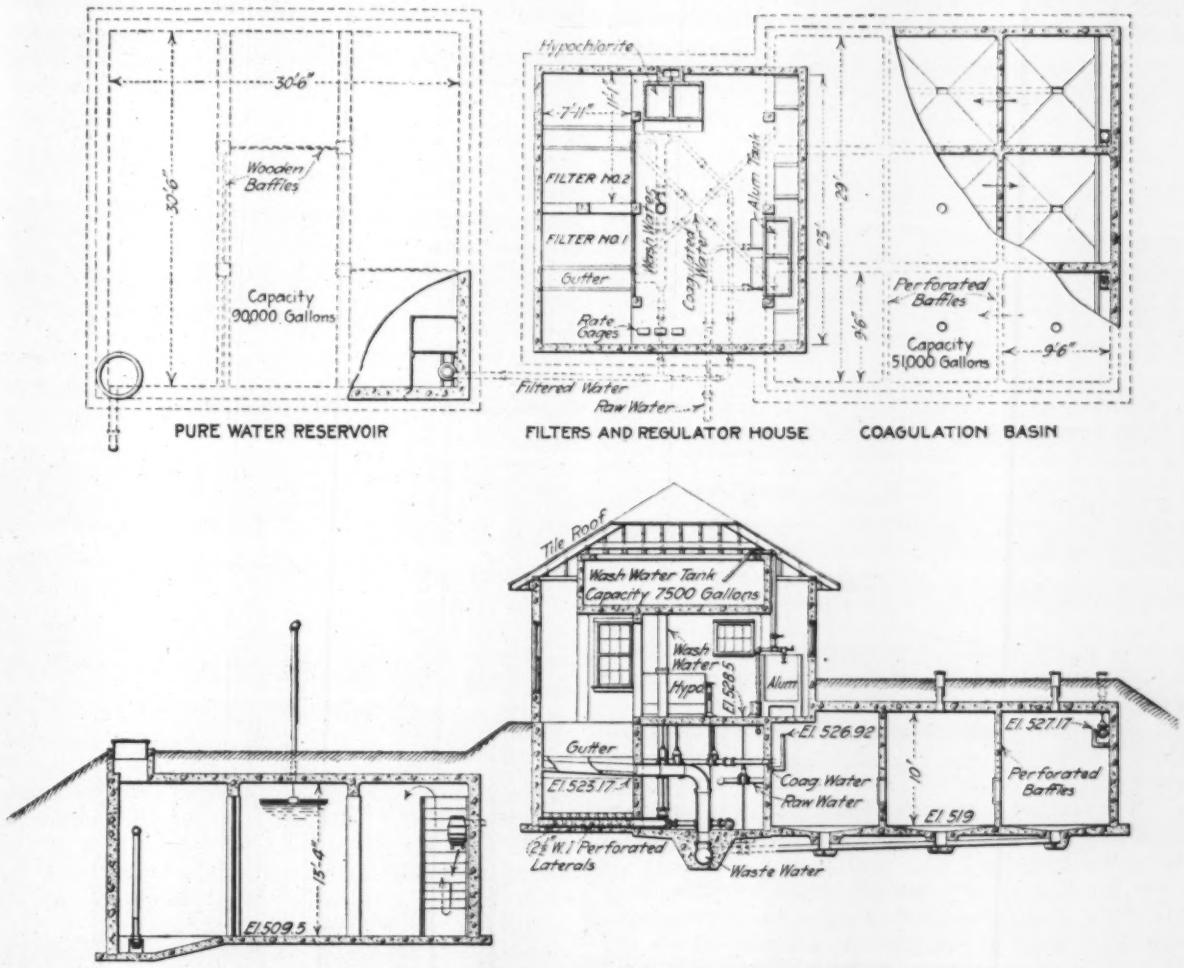

FIG. 1. PLAN AND SECTION OF WATER-PURIFICATION WORKS, FRANKLIN FURNACE, N. J.

The pipe gallery occupies the space below the operating floor between the filters and coagulating basin. All of the piping is cast-iron hub-and-spigot pipe, except the wrought-iron laterals and pressure pipes and lead pipes for chemical feed.

A 15-in. tile drain serves to convey to the river the sludge from the coagulating basin and the waste wash from the filters.

A wash-water tank of reinforced concrete (Fig. 1) occupies the upper part of the regulator house. It has a

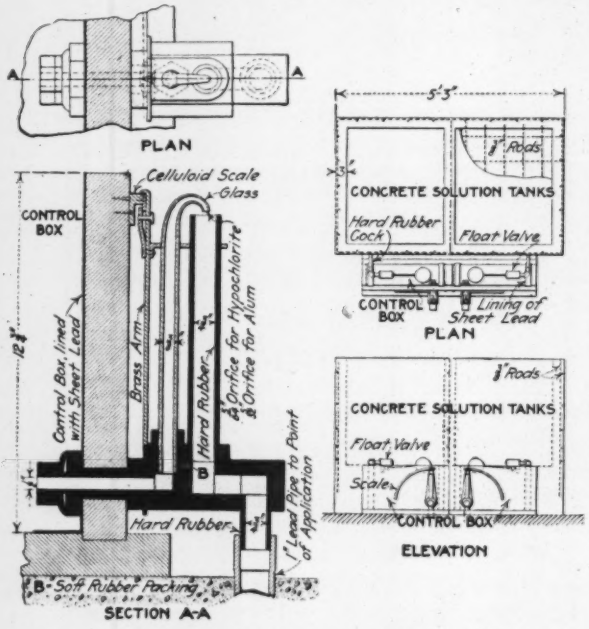

FIG. 2. DETAILS OF ALUM AND HYPOCHLORITE APPARATUS, FRANKLIN FURNACE, N. J.

capacity of 7,500 gal., a quantity somewhat in excess of that required to wash one filter. It is filled from a 3-in. service pipe. The concrete was poured at one operation and is of the same grade as was used in other parts of the plant. When the concrete was 36 hr. old the inside forms were stripped and the bottom and sides were painted with two coats of neat-cement grout. No waterproofing was used. The tank is entirely tight, no dampness showing on the outside.

On the floor of the regulator house, over the inlet end of the coagulating basin, are two alum tanks, each with an independent feed control. The coagulant is applied by gravity to the top of the raw-water inlet pipe just before it enters the coagulating basin. No elaborate means are employed to secure uniform dissemination of the coagulant, but the baffle plate in front of the inlet pipe serves this purpose to a considerable extent. The capacity of each tank is 269 gal., or 14 hr. flow at the maximum rate. From points about 2 in. above the bottoms of the alum-solution tanks, which are 14 in. above the operating floor, ¾-in. hard-rubber pipes lead through cutoff cocks and float valves to two lead-lined control boxes which stand on the floor in front of the main tanks (see Fig. 2). The outlet and control device is built entirely of hard rubber or glass and is mounted on the front wall of each control box and consists of a tube which may be clamped at any position on the arc of a circle, from the vertical to the horizontal, and which terminates in a circular glass nozzle $\frac{5}{32}$ in. in diameter. The alum solution flows from the constant-level control box through the sleeve joint at the center of the arc and up to the nozzle, through which it discharges freely into a tube connecting with a 1-in. lead pipe leading to the point of application of the coagulant.

The scale divisions on the arc are inches and tenths of inches, with zero at the top. The nozzle requires calibration. The discharge is very nearly directly proportional to the scale settling; the maximum rate is approximately 20 c.c. per sec.

The hypochlorite tanks and feed controls are in duplicate and are similar to those for the alum, but have a capacity of only 116 gal. each, or 20 hr. flow at the maximum rate. The discharge nozzle is $\frac{5}{64}$ in. in diameter, and the maximum rate is approximately 6 c.c. per sec. The hypochlorite is applied by gravity to the effluent pipe from the filters at a point outside the regulator house about 15 ft. from the inlet to the pure-water reservoir.

There are three venturi meters—one for the raw water and one for the effluent from each filter.

The indicating venturi-meter rate gages (Fig. 3) are somewhat out of the ordinary. They consist essentially of two tubes, the lower ends of which lead, one to the barrel and the other to the throat of the meter tube; from the upper ends the air is exhausted by a Richard's filter pump until such a degree of vacuum is created as will lift the water in the barrel connection to the zero of the scale, where it is maintained as long as the pump is

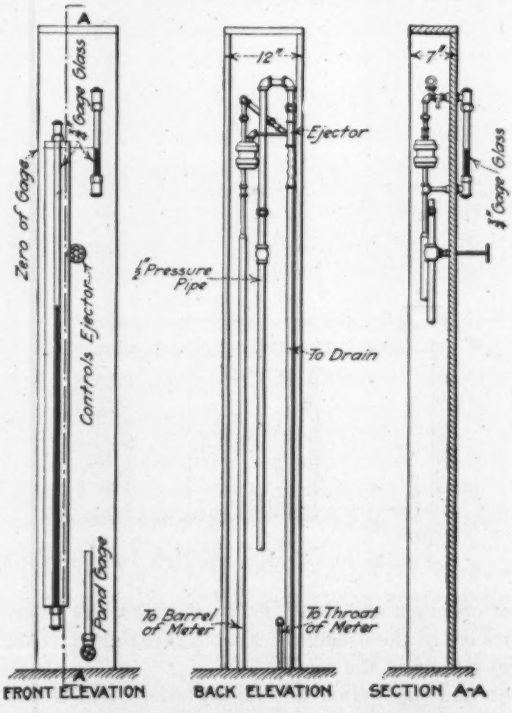

FIG. 3. VENTURI METER RATE GAGE

operated. As the top of the two tubes are cross-connected, the same vacuum exists in both; consequently the difference between the pressures at the throat and at the barrel is measured by the distance from the zero down to the level of the water on the throat tube. The scale is computed for each meter tube. Gages of a similar type have been in use for several years at the filtration plants at Yonkers and Ogdensburg, N. Y.

The loss of head through the filter is ascertained by means of a gage of the float type, by deducting the elevation of the water on the filter from the float-gage reading.

Pure-Water Reservoir Arrangement

The pure-water reservoir is of reinforced concrete and has a capacity of 90,000 gal. It is immediately adjacent to the regulator house, but is built entirely separate.

The calcium hypochlorite is applied to the water before it enters the pure-water reservoir. On entering, it first passes through close baffles which serve to thoroughly mix the disinfecting agent and which have a minimum period of detention of 30 min. The main baffles, as well as the hypochlorite baffles, are of wood.

Operation of the Filter Plant

In a plant as small as the one under consideration the cost of attendance is the determining factor in the cost of operation. Automatic appurtenances, of course, minimize the attendance necessary, but for a very small installation their first cost more than overbalances this saving.

There are no recording gages, no mechanically operated gates and no automatic rate controllers in the equipment of this plant. The attendant spends about an hour morning and evening at the filters.

A very liberal period of sedimentation (7.7 hr. nominal at the maximum rate) has been provided in order that the fluctuations in the raw-water rate will not disturb the filter operations, and in order to provide sufficient capacity in case the filters are ever operated at a higher rate than is now necessary.

Ordinarily, the filters are in service alternately and are allowed to run for about 12 hr. before being washed. The length of run could be increased to 16 or 18 hr. before the loss of head would compel washing, but for practical reasons of convenience this has not been done.

Low Rate of Filtration

The rate of filtration is from 50 to 70 million gallons per acre per day with one unit in operation. This low rate is advisable on account of the infrequent attention which the filters receive. The rate at the beginning of the run is about 140,000 gal. per day and after 12 hr. this has, as a rule, fallen to about 110,000 gal. per day. The factors which control the rate are the level of the water on the filter, the loss through the filter and piping, position of the gate on the effluent pipe and the level of the water in the pure-water reservoir. The level on the filters depends on the pond level, the frictional losses through the system to the filter, and the position of the raw-water gate. The loss of head through the filter and the level of the water in the pure-water reservoir are the two controlling factors, which alone need to be considered during any one run. The level in the pure-water reservoir has no effect when it is below the inlet, but as it rises above this point it reduces the effective head on the filter and consequently the rate. Should the pure-water reservoir fill completely before the attendant arrives, the filters continue to operate, but at a reduced rate, and the effluent is wasted to the drain. The filters are washed with filtered water at a rate of 2 ft. vertical rise per minute. The washing is continued for 5 or 6 min., or until observation shows the bed to be sufficiently cleaned. The procedure in washing is to drain the water on the filter down to about 2 in. above the sand, then, with the wash-water tank full, to slowly turn on the wash water, increasing to the full rate as soon as the top of the sand is broken up, and maintaining the full rate to the end of the wash. The wash-water valve has been calibrated so that the number of turns required to give the 2-ft. rate is known.

Should the rate of filtration fall below the raw-water rate, the water on the filter will rise until it overflows the dividing wall between the two filters and waste to the drain through the wash-water trough of the unit which is out of service.

The normal flow line of the coagulating basin is only enough below the low-water level of the pond to get head to maintain the required flow; consequently when the level of the water on the filter rises it reduces the raw-water flow by backing up into the coagulating basin.

Performance of the Plant

The plant has been in operation for about a year, and the quality of the water produced is thoroughly satisfactory. The infrequent attendance makes it necessary to be certain that at no time shall there be a deficiency of alum. The amount of alkalinity in the water makes a liberal application of alum entirely safe so far as any danger of acid water is concerned. The resultant color is unusually low, being for the greater part of the time below three, which is the value of the lowest color standard used, and consequently it is recorded as having zero color.

This procedure is open to the criticism that it is uneconomical of coagulant, but the total amount used is so small that even with the most careful regulation the saving would not amount to over $30 to $40 per year. The certainty of good operation and a practically colorless water are well worth this expense.

The bacterial results have been consistently good. The count at 48 hr. on lactose agar ranges from 0 to 3 per c.c. for tap water (raw water 40 to 500 per c.c.). After storms the lactose bile test has given positive results from 1 c.c. of raw water, but in no case have positive results been obtained from 10 c.c. of tap water.

The daily records are kept by the card-index system on four blank forms—one showing alum and hypochlorite feed, one for filter operation, one for chemical and bacterial results, and one for B. coli.

David Jenkins, chemist of the New Jersey Zinc Co., has been in charge of the plant since it was put in operation by the writer, who had charge of construction.

Building Regulation Advance in Pennsylvania—A short act passed by the legislature of Pennsylvania at its 1915 session and since approved by the governor, will interest those who believe that American cities should exercise more control than they do over the character and use of buildings in different parts of the city. The act reads:

That, for the purpose of promoting the public health, safety, order and general welfare, cities of the first class may regulate the location, size and use of buildings therein and may make different regulations for different districts thereof. The park commission of any city of the first class may make such regulations as to the location, size and use of buildings, any portion of which shall come within 200 ft. of any park, parkway, playground or other public place under its care or management, and upon their approval by the councils of such city, said regulations shall have the same effect as if originally made by said councils.

Although it appears that this act applies only to buildings within 200 ft. of a park or other public land in the care of a park commission of a city of the first class, even that measure of control is a step in advance.

Construction and Operation of Gloversville Sewage Works--II

By H. P. Eddy* and H. J. Hanmer†

SYNOPSIS—Operating results of a 3,000,000-gal. plant consisting of screens, primary tanks, sprinkling filters, intermittent sand filters and sludge pumps and beds.

Operating Methods and Results‡

The Gloversville sewage works has been in operation since Dec. 1, 1912. No means are available for measuring the flow of sewage, but it is estimated to be 2,750,000 gal. per 24 hr., of which about 74 per cent. is domestic sewage and the remainder manufacturing wastes.

Screenings—The coarse bar screen through which the crude sewage passes removes on the average about 4 cu.ft. of screenings per day and requires raking by hand from four to five times a day. This raking is all done between 8 a.m. and 5 p.m. at an expense of about $0.50 per day.

FIG. 6. SEWAGE SLUDGE ON GLOVERSVILLE DRYING BEDS

The primary-tank effluent is passed successively through three mesh screens, having openings ½, ¼ and ⅛ in. square, respectively. When one screen has collected a sufficient amount of material, it is replaced by a clean one, and the dirty screen is taken to the screen-washing house near-by, where it is cleaned by a stream of water from a ¾-in. hose. The material washed from the screens falls into the sludge-pipe line and is handled with the sludge. These screens are washed from four to five times during one 8-hr. shift each day, at a cost of $1.50 per day, and the resulting screenings amount to approximately 4 cu.ft. per week under normal conditions, but in times of heavy rains with a flow of about 6,000,000 gal. per day the amount has been increased to 5 cu.ft. per day. The screenings consist largely of small bits of fat, much of which probably comes from the tanneries, and burnt matches.

Primary-Tank Sludge—The production of sludge in the primary settling tanks has amounted on the average to about 9 cu.yd., or 1,817 gal., per 1,000,000 gal. of sewage treated. When the plant was first placed in operation the sludge was drawn off once every two weeks, but it was soon found that better results were obtained when the sludge was drawn off three times each week, as is now the practice.

Secondary-Tank Sludge—The sludge from the secondary settling tanks, receiving trickling-filter effluent, is drawn off once each week. The quantity produced varies from about 0.8 cu.yd. per day in the winter to about 2.5 cu.yd. per day in the spring when the trickling filters are unloading the deposits on the stone.

Sludge Disposal

In disposing of the sludge it is pumped from the storage well onto sand drying beds (Fig. 6) and when sufficiently dry is removed by teams. In the spring and fall the farmers take nearly all of it, and at other times it is used for fertilizer on city land or for filling low areas. The cost of operating the sludge beds during the year 1914 was $1,000, practically all of which was expended in handling dried sludge. It does not include the cost of pumping the wet sludge.

Dosing Tank—The quantity of sewage discharged per dose by the dosing tank is about 16,720 gal., more than half of which is stored in the collector troughs and conduits in the primary settling tanks. When two acres of sprinkling filters are in use, the time for the discharge is 3½ min., and the rest period varies from 12 min. for the minimum night flow to 6 min. for the maximum day flow.

Trickling Filters—It has been customary to use two acres of the trickling filters at a time, allowing one acre to rest. The period of rest varies from 6 or 7 days in the winter to 2 or 3 days in the summer. During the rest period in the warm weather, the deposit and growth on the stones dry up and wash out into the secondary tanks when the filter is again dosed.

It is interesting to note that the upper layers of stone harbor vast numbers of snails, small fish worms and flies. Examinations of the stone by means of test pits show that growths and deposits are not formed at a greater depth than 8 to 10 in. below the surface, the remainder of the stone and the floor system being substantially clean.

Out of the 930 nozzles (Taylor type) on the three acres of filters, 620 are usually in operation at each dose. On the average, about 60 nozzles require cleaning each day, half in the morning and the remainder in the afternoon. No nozzles are cleaned between 5 p.m. and 8 a.m. The clogging of nozzles is usually caused by burnt matches and grease, and the trouble can usually be remedied by releasing the spindle of the nozzle and allowing the sewage at the next dose to flow through the dome and wash out the obstructions.

Some trouble has been experienced with an incrustation which forms on the under side of the spindle and on the inside of the dome. This has a tendency to lengthen the period of dose and also to cut down the area of distribution. To remove this incrustation, which is done

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†City Engineer, Gloversville, N. Y.

‡The design, construction and itemized cost of this plant were given in "Engineering News," Oct. 14, 1915, p. 744.

twice a year, it is necessary to take off both the spindle and dome and immerse them in a solution of one part water and two parts hydrochloric acid. With a few exceptions there has been no trouble with the distributors, and there has been none at all with the underdrains.

There is but little odor from the trickling filters, especially on week days. What little there is, is from the tannery wastes. On Sundays the odor is a little more pronounced and resembles that of ordinary sewage, but the distance from the filters that it is noticeable does not ordinarily exceed 200 ft.

During the warm weather in the summer little gray flies which breed in the stone of the trickling filters are a source of great annoyance. During the first summer of operation, a tannery that is situated about 200 ft. from the filters, in the path of the prevailing wind, was caused

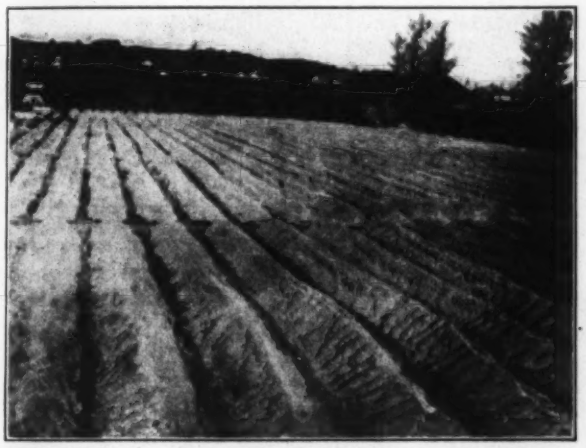


FIG. 7. GLOVERSVILLE SAND FILTERS RIDGED FOR WINTER USE

considerable inconvenience from these flies, which could get into the skins as they were being tanned. When the flies first make their appearance, bleach (calcium hypochlorite) is applied to the sewage in the dosing tank, 12 lb. of dry bleach being applied to each of three doses in one day, and the operation repeated on the second day following. It was necessary to carry out this treatment on two different occasions during the summer of 1914. It does not appear to kill the fully matured flies, but does kill the larvæ and very young flies and results in a marked reduction in the objectionable conditions.

The original designs provided that the trickling filters should be inclosed during the winter months to protect them from the snow and cold. Owing to the lack of funds in 1912, no covering was provided, and although a very mild winter followed, the ice at times covered two-thirds of the filter area. In the fall of 1913 temporary roof and sides of rough hemlock lumber were provided, requiring 120,610 ft. b.m., costing $4,177, or $1,360 per acre.[1] The annual cost for removing the covering in the spring and replacing it in the fall is about $300. The covering was removed in the spring of 1914 at a total cost of $143, with a force of 6 to 8 men, in 13 days, starting on Mar. 24. The covering was replaced in the fall of 1914 at a cost of $157, with a force of 3 to 4 men in 26 days, starting on Nov. 18.

[1]See "Engineering News," Apr. 9, 1914, for winter views of beds without and with protection, and further details of covering in article by Mr. Hanmer.—Editor.

If the inclosure is made tight, a dense vapor forms during very cold weather, between the top of the filters and the roof, making it extremely difficult for the attendant to see the nozzles that require cleaning. The air in the inclosure is very bad. To remedy these troubles an occasional board is left off the roof and a number of doors on the sides are left open to provide for ventilation.

Sand Filters—Between the hours of 10 a.m. and 5 or 6 p.m. the effluent from the secondary tanks is the strongest, and this portion is turned onto the sand filters for further treatment. The surface of the sand along the distribution troughs and in the low places becomes clogged frequently with a jelly-like deposit which dries very slowly. Two sand filters only are operated at a time, thus giving opportunity for cleaning the third one. Although some trouble is experienced with growths of weeds and grass during the summer, it is seldom necessary to rake the entire surface of the beds by hand, if a horse-drawn weeder is used to stir up and loosen the surface five or six times during this period. In the winter the surface of the sand filters is furrowed (Fig. 7), the ridges being about 2½ ft. c. to c. and the furrows about 18 in. deep, in order to support the ice sheet that forms on the filters and might otherwise freeze to the sand and thus put the entire bed out of use. The cost of furrowing in the fall is about $58; the cost of leveling the ridges in the spring is about $25, and the cost of cleaning is about $165.

TABLE 4. AVERAGE RELATIVE STABILITY OF GLOVERSVILLE SEWAGE EFFLUENT BY MONTHS, 1914

(Expressed in percentages)

Month	Temperature of Air Minimum	Temperature of Air Mean	Trickling Filters	Effluent from Secondary Settling Tanks	Sand Filters
January	—25	18.6	35.2	36.5	100
February	—25	11.8	68*	68*	100
March	0	27.8	75	75	...
April	19	48	65	68	100
May			52	58	100
June			55	62	100
July			51	58	100
August			62	64	100
September			57	62	100
October			62	69	100
November	12	38	65	67	100
December	—30	22	46	51	100

*Samples were not decolorized at the end of 5 days, when they were thrown away.

Stability of Effluents—Table 4 shows the relative stability of effluents from the trickling filters, secondary settling tanks and sand filters, incubated at a constant temperature of 68 deg. F. Samples were taken and incubated every afternoon at about 4:30 o'clock, according to "Standard Methods of Water Analysis."

Cost of Operation

Table 5 shows the cost of operation by items for the years 1913 and 1914.

TABLE 5. COST OF OPERATION OF GLOVERSVILLE SEWAGE-TREATMENT WORKS, 1913 AND 1914

	1913	1914
Supervision by city engineer	.....	$600.00
Operation of screens, etc.	$223.37	574.00
Sludge pumping, labor and repairs	318.34	214.05
Electric power	318.34	214.05
Maintenance of trickling filters:		
Nozzles	897.28	395.00
Removing and replacing covering	278.25	359.00
Maintenance of sludge beds	1,312.46	1,235.00
Cleaning troughs of secondary tanks	35.50	19.63
Maintenance of sand filters	440.33	315.00
Maintenance of grounds	399.97	163.00
Miscellaneous work	169.87	365.00
Chloride of lime and other supplies	835.96	664.27
Telephone	42.00	42.00
Cleaning and repairs to east primary settling tank (this is an unusual item)	.....	709.00
Total cost for year	$5,179.33	$5,951.95
Cost per million gallons treated	5.16	5.92
Cost per capita based on estimated population	0.24	0.27
Estimated population	21,600	21,800

"Dan Patch" Railway Uses Only Gasoline Power*

The Minneapolis, St. Paul, Rochester & Dubuque Electric Traction Co., operating what is popularly called the "Dan Patch Electric Lines," has what is believed to be the first railway operated entirely with gasoline motive power. The company has recently placed in service three 60-ton gasoline-electric locomotives for freight, passenger and terminal service. It already has a 57-ton locomotive of similar design and 13 gasoline-electric motor cars.

The railway line runs south from a terminal building on 7th St., Minneapolis, for 107 mi. to Mankato. From the middle of the line a branch runs northeast from Northfield to Randolph, 7 mi. Another extension is projected from Faribault southeast to Dubuque, Ia.

There are few difficulties in railroad construction throughout this territory, the severest grade on the line being 2%. In the various cities and towns substantial stations have been erected similar to those used by steam roads. Shelters have been erected every few miles at rural stops. Four through trains are run daily each way and constitute the normal schedule. A parlor-car limited makes the 107-mi. run in 3 hr. 25 min. The other trains require 4 hr. 5 min. Between certain points of the line and the terminals local service is given. In the summer season such excursion trains are run as occasion demands.

These various runs are usually made by a 70-ft. gasoline-electric motor car seating 89 passengers. For a moderate increase in travel a trailer car is added to this and for excursions and extra-heavy traffic a train is made up of trailers and a 60-ton gasoline-electric locomotive of the type shown in the accompanying view.

The new locomotives are double ended and have all the weight on drivers. The box cab extends nearly the entire length of the underframe, which is carried by two two-motor trucks. The cab is arranged in a single compartment and has in it two generating sets. Only one engineman is required. The generating sets and motor controllers are in each end of the cab, convenient to the engineer's seat. The auxiliary lighting set, air compressors and air-storage tanks are assembled in the middle.

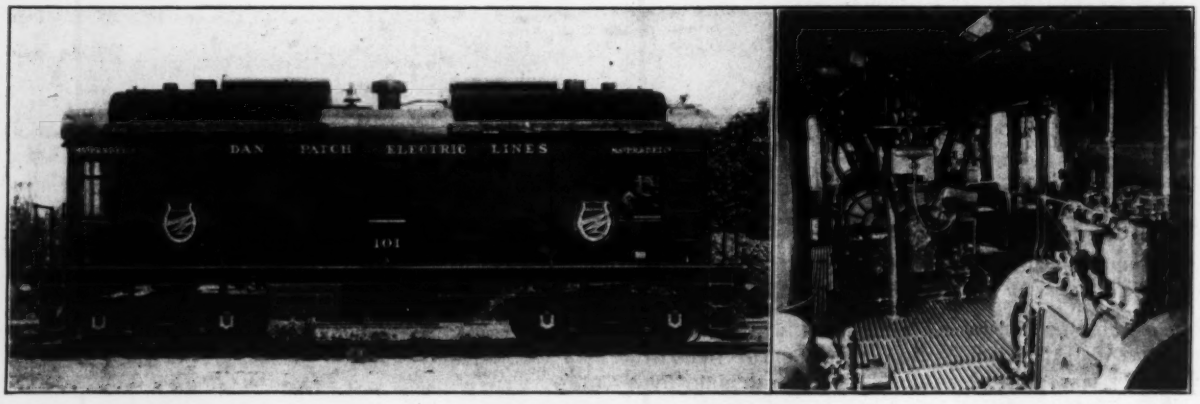
*From data furnished by the makers of the gasoline-electric equipment of this road, the General Electric Co., Schenectady, N. Y.

The cab is of all-steel construction—side posts and rafters of T-irons and angles covered with sheet-steel plates having riveted lap and butt joints. The underframe consists of outside and center sills made up of two 10-in. 30-lb. longitudinal channels. These are tied together by cast-steel buffer end frames and bolster plates (12x1⅛ in.). Cast-steel center plates are bolted to the bolster plates, and cross-sills are riveted in where necessary to support equipment slung below. The drawhead castings are attached to the center sill.

The trucks are a four-wheel swivel type with plate-frame swing bolsters. The wheels are 33 in. in diameter. The axles are 6½ in. in diameter between wheels and 5½x10-in. journals.

A combined straight and automatic air-brake system is used, with 16-in. brake cylinders. About 85% of the weight on the drivers is exerted by the brakeshoes with 50-lb. pressure in the brake cylinders.

Each of the generating sets has a 175-hp. 550-r.p.m. 8-cylinder gasoline engine directly connected to a 600-volt compound-wound commutating-pole generator. The cylinders are arranged in V-pairs and are of 8-in. diameter and 10-in. stroke. Ignition is from low-extension magnetos. The sets are started by air pressure; but with one set running, the second set may be started electrically. Either or both of the generating units may be used to operate the locomotive in either direction, according to the requirements of the train load.



OUTSIDE AND INSIDE OF GASOLINE-ELECTRIC LOCOMOTIVE ON "DAN PATCH" RAILWAY

Compressed air for starting is taken from the main reservoirs of the air-brake system, which are accordingly built with surplus capacity. There are two single-cylinder compressors, driven from the main crankshafts.

Each of the four motors on the truck is a 100-hp. 600-volt type. The gear ratio is 58 to 17, which is well adapted for freight-terminal switching. The motors are suction-ventilated by the engines. The tractive effort at starting is 32,200 lb. At 4 mi. per hr. it is 18,000 lb.; at 8 mi. per hr., 12,000 lb.; at 16 mi. per hr., 6,800 lb., and at 48 mi. per hr. it is 1,000 lb.

The principal dimensions are tabulated below:

Total net weight, equipped	120,000 lb.
Weight per axle	30,000 lb.
Maximum tractive effort	32,200 lb.
Length between coupler knuckle faces	41 ft. 4 in.
Length over cab	34 ft.
Height over all	14 ft. 10¾ in.
Width over all	10 ft. 2 in.
Total wheel base	24 ft.
Rigid wheel base	6 ft. 10 in.

Cincinnati Rainfall Averages

By Harry R. Crohurst*

In connection with the articles in *Engineering News* of June 24, 1915, on the length of record necessary to determine the average rainfall for a given locality, it may be of interest to compare the 65-yr. record of Cincinnati, Ohio, with the 100-yr. New Bedford, Mass., record in accordance with the method for the latter used by Mr. Stineman.

The Cincinnati record is made up from the observations of Dr. Joseph Ray and others (1850-55), Prof. George W. Harper, of Woodward High School (1856-65), reports of R. C. Phillips (1866-70) and the United States Weather Bureau from 1870 to date. The average annual rainfall during this period was 39.23 in.

Table 1 shows the annual rainfall and the average for 5- to 25-yr. periods. The accompanying diagram shows these averages arranged graphically, except that the 5-yr. averages are omitted.

From an inspection of these data it will be seen that the 5-yr. averages range from 51.60 to 29.46 in., or 31.5% above to 24.9% below the mean rainfall for the whole period.

The 10-yr. averages vary from 46.87 to 32.57 in., or 19.5% above to 17% below the mean; 55% of the time it was above the mean and 45% below.

The 15-yr. averages vary from 43.54 to 33.70 in., or 11% above to 13.9% below the mean; 60% of the time it was above the mean and 40% below. Expressed another way, the 15-yr. average is within 5% of the mean either way 33% of the time or within 10% of the mean either way 65% of the time.

The 20-yr. average varies from 43.33 to 34.18 in., or 10.5% above the mean to 12.9% below; 61% of the time it was above the mean and 39% below. The average for 20 yr. is within 5% of the mean 40% of the time and within 10% of the mean 80% of the time.

TABLE 2. RELATION BETWEEN AVERAGE FOR 25 AND 65 YEARS

Per Cent. Above or Below the Mean for the Whole Period	Per Cent. of the Time During Which the 25-Yr. Average Was Within the Per Cent. (Given in the First Column) of the Mean
1	2
2	5
3	32
4	39
5	49
6	60
7	68
8	80
9	88
10	93
11	98
12	100

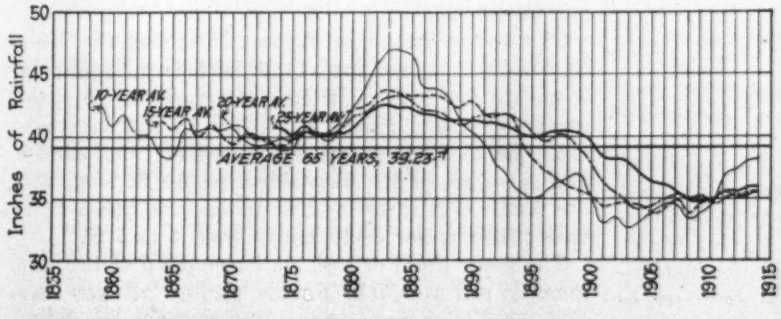
The 25-yr. average varies from 42.38 to 34.89 in., or 8% above to 11% below the mean; 66% of the time it was above the mean and 34% below. Using in this case the 25-yr. average, the result would be within 5% of the true mean 40% of the time and within 10% of the true mean 93% of the time.

On the basis of a 25-yr. average, Table 2 shows the time and percentage during which the 25-yr. mean would vary from the mean of the whole period.

It is interesting to note that in using 15-, 20-, or 25-yr. averages about two-thirds of the time the assumed average would be above the true mean and one-third of the time below the true mean. Also that the variation from the mean is less when the 15-, 20-, or 25-yr. average is above the mean than when it is below it.

TABLE 1. ANNUAL AND AVERAGE RAINFALL AT CINCINNATI, OHIO, 1850 TO 1914

Year	Annual	Averages for Periods of Years: 5	10	15	20	25
1850	54.76	.....	.....	.....	.....	.....
1851	32.49	.....	.....	.....	.....	.....
1852	54.35	.....	.....	.....	.....	.....
1853	40.10	.....	.....	.....	.....	.....
1854	50.77	46.49	.....	.....	.....	.....
1855	46.73	44.89	.....	.....	.....	.....
1856	22.88	42.97	.....	.....	.....	.....
1857	34.90	39.08	.....	.....	.....	.....
1858	49.17	40.89	.....	.....	.....	.....
1859	42.57	39.25	42.87	.....	.....	.....
1860	33.84	36.67	40.78	.....	.....	.....
1861	42.31	40.56	41.76	.....	.....	.....
1862	38.83	41.34	40.21	.....	.....	.....
1863	40.05	39.52	40.21	.....	.....	.....
1864	34.51	37.91	38.58	41.22	.....	.....
1865	44.58	40.06	38.36	40.54	.....	.....
1866	46.90	40.97	40.77	41.50	.....	.....
1867	32.10	39.63	40.49	40.02	.....	.....
1868	50.71	41.76	40.64	40.72	.....	.....
1869	41.51	43.16	40.53	40.11	41.70	.....
1870	36.19	41.48	40.77	39.40	40.77	.....
1871	32.07	38.52	39.75	40.02	40.75	.....
1872	34.89	39.07	39.35	40.02	39.78	.....
1873	41.38	37.21	39.48	39.50	39.84	.....
1874	37.61	36.43	39.79	39.17	39.19	40.65
1875	42.58	37.71	39.59	39.75	38.98	40.16
1876	52.62	41.82	40.17	40.44	40.47	40.97
1877	34.65	41.77	40.42	40.16	40.45	40.18
1878	41.62	41.82	39.51	40.26	40.08	40.24
1879	51.60	44.61	40.52	41.40	40.53	40.27
1880	54.67	47.03	42.37	42.07	51.57	40.59
1881	47.24	45.96	43.89	42.10	41.82	41.56
1882	52.12	49.45	45.61	43.43	42.48	42.25
1883	52.35	51.60	46.71	43.54	43.10	42.38
1884	39.28	49.13	46.87	43.39	43.33	42.25
1885	33.94	44.99	46.01	43.24	42.80	42.25
1886	31.35	41.81	43.88	43.19	42.02	41.81
1887	35.08	38.40	43.93	43.21	42.17	41.66
1888	34.88	34.91	43.25	42.77	41.38	41.46
1889	30.92	33.23	41.18	42.33	40.85	41.31
1890	47.70	35.99	40.49	42.67	41.43	41.44
1891	38.44	37.40	39.61	41.72	41.75	41.10
1892	31.95	36.78	37.59	41.54	41.60	41.09
1893	44.00	38.60	36.75	41.70	41.73	40.83
1894	26.59	37.74	35.49	40.03	41.18	40.23
1895	29.33	34.06	35.02	38.34	40.52	39.95
1896	34.48	33.27	35.34	37.49	39.61	40.05
1897	43.89	35.66	36.22	36.95	40.07	40.41
1898	38.97	34.65	36.63	36.05	39.94	40.31
1899	34.09	36.27	37.00	35.75	39.09	40.20
1900	27.78	35.96	35.01	35.34	37.75	39.61
1901	17.99	32.66	32.97	34.45	36.29	38.22
1902	37.30	31.35	33.50	34.59	35.55	38.33
1903	34.69	30.49	32.57	34.58	34.66	38.05
1904	29.54	29.46	32.87	34.49	34.18	37.17
1905	38.69	31.64	33.80	33.89	34.41	36.53
1906	40.83	36.21	34.44	34.05	34.89	36.27
1907	44.56	37.66	34.50	34.89	35.36	35.97
1908	27.29	36.18	33.34	33.77	34.98	34.97
1909	37.43	37.76	33.61	34.50	35.31	34.89
1910	34.42	36.91	34.27	34.84	34.64	34.91
1911	45.05	37.75	36.98	35.54	34.97	35.46
1912	38.61	36.56	37.11	35.19	35.31	35.60
1913	42.15	39.53	37.86	35.40	35.21	35.89
1914	32.78	39.60	38.18	35.27	35.52	35.97



AVERAGE RAINFALL, CINCINNATI, OHIO, FOR THE 65 YR. 1850 TO 1914, COMPARED WITH 5- TO 25-YR. PERIODS

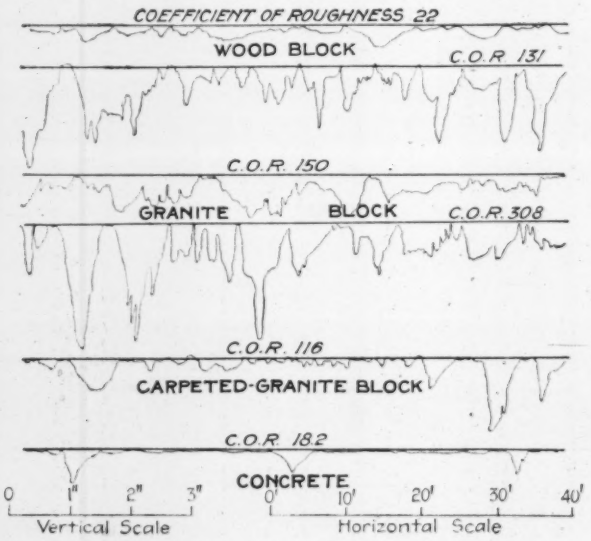
*Sanitary Engineer, U. S. Public Health Service, Cincinnati, Ohio.

Tests of Smoothness Made on Various Pavements

By R. D. Kneale*

With the Kneale testing machine for smoothness of pavement surfaces, described in *Engineering News*, Oct. 14, 1915, p. 751, some interesting studies were made of pavements in Fulton County and Atlanta, Ga. By the use of this machine the coefficients of roughness given in the accompanying table were determined. The coefficient of roughness, as defined in the article previously referred to, is the sum of vertical drops in the pavement surface in feet per mile.

In Table 1 column 1 gives the type of pavement, column 2 its age in years, column 3 its coefficient of roughness (feet per mile), column 4 the average tons traffic carried per day, column 5 the average speed of such traffic, column 6 the estimated maximum traffic carried



TYPICAL RECORDS OF PAVEMENT SMOOTHNESS

by any yard of the pavement's width from construction to date and column 7 gives the estimated percentage of motor traffic as compared with all traffic on dates of census.

TABLE 1. SMOOTHNESS TESTS ON VARIOUS TYPES OF PAVEMENT

	1 Type of Pavement	2 Age in Yrs.	3 Coeff. of Roughness	4 Tonnage per Day	5 Speed in Mi. per Hr.	6 Total Tons Carried per Yd. of Width	7 Percentage of Motor Traffic
No. 1.	Sheet asphalt	8	15.4	10,000	16	5,210,000	92
No. 2.	Sheet asphalt	8	46.2	200	3	270,000	50
No. 3.	Wood block	7	22.0	11,000	8	3,150,000	70
No. 4.	Wood block	7	131.0	5,500	12	850,000	65
No. 5.	Grouted granite block	4	150.0	2,500	12	824,000	70
No. 6.	Granite block on soil	25	308.0	3,200	5	2,380,000	40
No. 7.	Granite block carpeted	½	116.0	2,000	15	66,000	85
No. 8.	Concrete	¼	18.2	150	25	60,000	95
No. 9.	"Bitulithic"	5	16.5	2,000	15	730,000	85
No. 10.	Asphaltic concrete	7	132.0	1,800	10	640,000	65
No. 11.	Asphaltic macadam	½	58.0	1,200	15	50,000	80
No. 13.	Asphaltic macadam	3	196.0	1,100	12	385,000	85
No. 14.	Top-soil	½	23.0	120	10	12,000	50
No. 15.	Brick	½	17.2	800	15	50,000	65
No. 16.	"Roc-Mac"	New	60.5	000	...	.....	..

The test on pavement No. 2 was parallel to No. 1, but was taken in the gutter, where lack of traffic and excess of water from flushing have put the asphalt in bad condition. Test No. 4 was taken between the car tracks, where any combination of factors may have dominated—poor foundation, inadequate drainage and expansion or too light rails. Pavement No. 6 was reset two years ago by convict labor. Resetting improved it very little. By carpeting pavement No. 7 its coefficient of roughness was reduced from 250 to 116. Test No. 8 demonstrates the smoothness of a well-constructed concrete road. About 40% of its coefficient was due to the expansion joints. By the time the coefficient for No. 13 had reached about 130, traffic began to abandon the street for a parallel macadamized street. This macadam was worn out by the excessive traffic in three months. No. 14 illustrates the top-soil road at its best. No. 15 shows a particularly good piece of brick pavement laid on soil. The brick are square-cornered and grouted.

After considerable study of the coefficients of the principal types of construction, the author presents the accompanying Table 2 of coefficients as approximately correct for the standard 6-in. wheel.

TABLE 2. PROPOSED ALLOWABLE COEFFICIENTS OF ROUGHNESS FOR NEW CONSTRUCTION AND FOR MAINTENANCE

Type of Pavement	Construction	Maintenance
Sheet asphalt	11	20
Asphaltic concrete	15	30
Asphaltic macadam	25	60
Waterbound macadam	50	100
Wood block	20	40
Grouted brick	35	80
Granite block	125	200
Concrete	25	50

Both construction and maintenance clauses should also specify a maximum allowable deviation of the graph from the base line, or datum (see accompanying figure). This allowance might well be approximately as shown in Table 3.

TABLE 3. PROPOSED ALLOWABLE DEVIATION FROM DATUM

Type of Pavement	Construction, In.	Maintenance, In.
Sheet asphalt	0.25	0.50
Asphaltic concrete	0.25	0.50
Asphaltic macadam	0.50	1.00
Waterbound macadam	0.75	1.25
Wood block	0.25	0.75
Grouted brick	0.25	0.75
Granite block	0.75	1.25
Concrete	0.25	0.75
Concrete at expansion joints	0.50	1.00

On analysis of the service given per unit expended, it is estimated that the asphalt of street No. 1 is carrying 7,080 tons per sq.yd. per yr. per cent expended on maintenance.

*Professor of Highway Engineering, Georgia School of Technology.

A Bridge Curio Fails--Are All Failures Fortuitous?

By "Bridgebuilder"

A highway bridge at Red Bank, N. J., failed on Sept. 23, 1915, under a motor truck. The full details are not available, but there are a number of points connected with the structure, and others of its class, of such vital interest to those having to do with highway bridges that a brief description of the salient features of this structure may be valuable.

The bridge, known as Hubbard's, crosses the Navesink River from Red Bank to Middletown township. It is an old and very light iron structure, of 10 spans, resting on iron cylinders, which in turn rest on rubble-stone piers. The general dimensions are approximate. The spans are of the bowstring type, 40 ft. long, with five panels of 8 ft. each. The trusses are spaced 17 ft. apart; their center depth ranges from 4 to 5 ft.

The upper chord or arch rib is composed of two 6-in. channels and two 6x¼-in. side plates. All web diagonals are ⅞-in. round rods. Web verticals are 3x3-in. cross-shaped bars forged down at the ends and threaded

for nuts. The lower chords are composed of two 3x½-in. flats, likewise forged down at the ends for nuts placed back of the main shoes. These bars are continuous from end to end of the span. Connections at the panel points are made through a series of clamps which grasp the lower-chord bars.

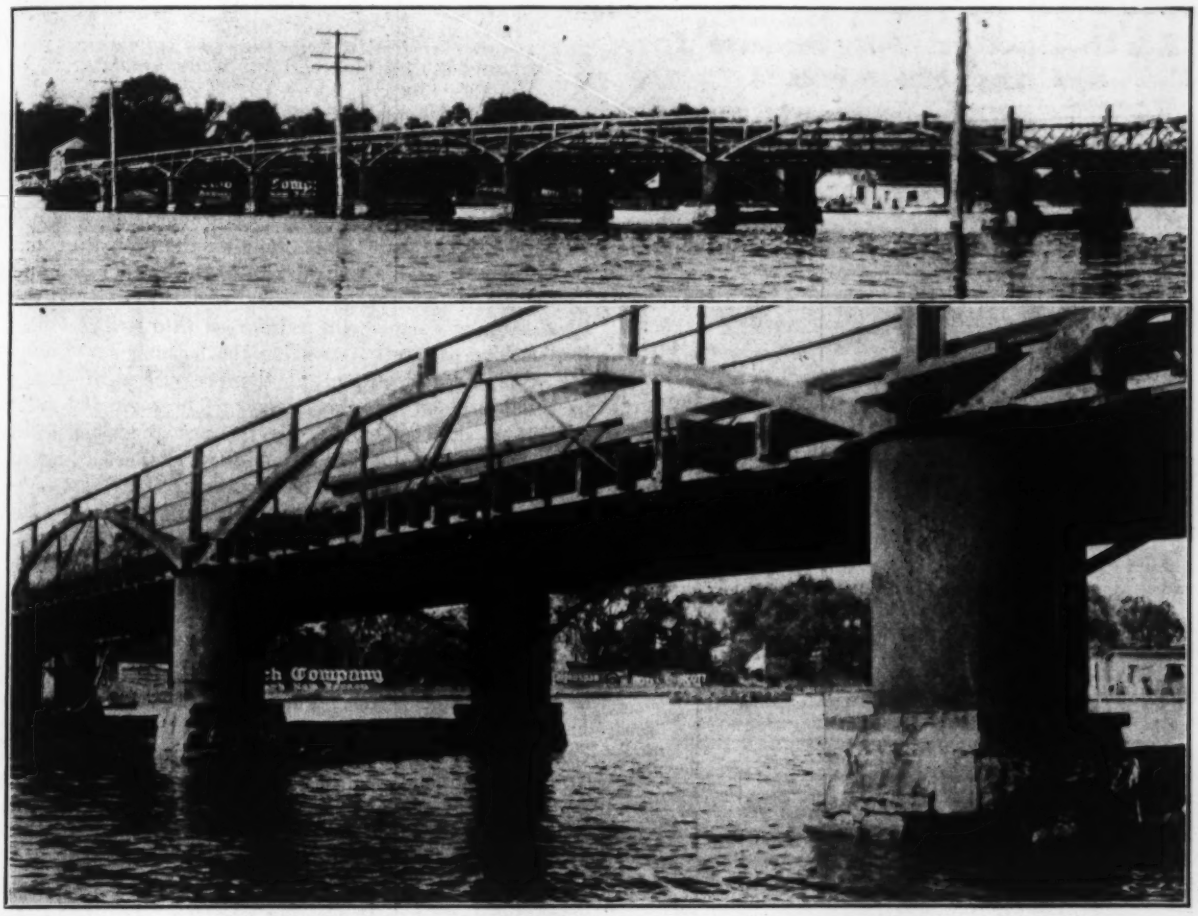
The lower laterals are ⅝-in. round rods. On the lower chord are placed the wooden floorbeams, which are 3x12 in., covered in turn with 2½-in. planking laid diagonally. These wooden floorbeams are notched about 2 in. over the lower-chord bars and are spaced 20 to 24 in. on centers. Next to each of the two center verticals in each truss is laid a 6-in. I-beam with its ends projecting outward beyond the trusses and having a wrought-iron strap fastened to the web, forming a socket for a diagonal brace to the upper chord. This brace is a cross-shaped iron bar forged down at the ends like the truss verticals. On the north side of the bridge is a footwalk about 5 ft. wide, the outer edge of which is carried by the latticed railing resting on light angle brackets attached to the sides of the cylinders. In order that the braces of the trusses should not interfere with the users of the sidewalk, they were omitted on the sidewalk side and nothing was substituted to brace the truss carrying the heavier load.

When the bridge was viewed a day or two after the failure, the truck had been removed and workmen were engaged in removing the bent I-beams in the floor which failed and in laying new wooden floorbeams in the same manner as the old. The lateral rods had not been repaired nor had the web rods in the outer truss been replaced or renewed. Apparently the truck only broke through the floor and pulled out the web rods of the truss without causing the truss itself to collapse—a bowstring truss can stand with little or no web-system.

The amazing fact remains that this remarkable contraption could carry highway loads for a long period of years. The location of the bridge was such that it carried considerable traffic owing to repairs being in progress on the only other bridge leading out of the town.

It is startling to note the great number of bridges which receive no attention or regular inspection by those who are responsible for their maintenance. It is also a cause for wonderment that the truck in this instance was able to get even halfway across this bridge before it broke through, for the lightness and poor condition of the bridge have been commented upon for years. Carelessness regarding bridge structures which are kept in service for the use of the public is little short of criminal. A few states exercise authority over those bridge structures which carry public utilities. New Jersey is foremost in this, having had for years an established system of regular inspections by competent engineers. But mere highway bridges are left wholly without supervision.

Such failures as this one are preventable. They only emphasize the need of placing all public bridges under



HUBBARD'S BRIDGE OVER THE NAVESINK RIVER, RED BANK, N. J.

the control and regulation of a competent and efficient bridge department, whose regular inspections would be the best insurance against similar failures.

The modern juggernaut, the auto-truck, ever increasing in weight and with its heavy axle concentrations, often leaves a wake of broken planks behind it. The passage of such heavy concentrations across a structure not designed for them often starts trouble which a subsequent lighter load will develop disastrously. One wonders what would be the consequence of such frequent and flagrant disregard of the laws of economics in case it became suddenly necessary to provide for the quick transportation of artillery over structures which would have to be rebuilt before such movement were possible.

Earth-Backed Abutments for Concrete Arches

One of the special constructions used in the great Detroit-Superior viaduct over the Cuyahoga River at Cleveland, Ohio, is an arch abutment which relies for stability upon the passive resistance of the earth backing. Sliding friction on the base of the abutment is disregarded. Certain precautions are employed in applying

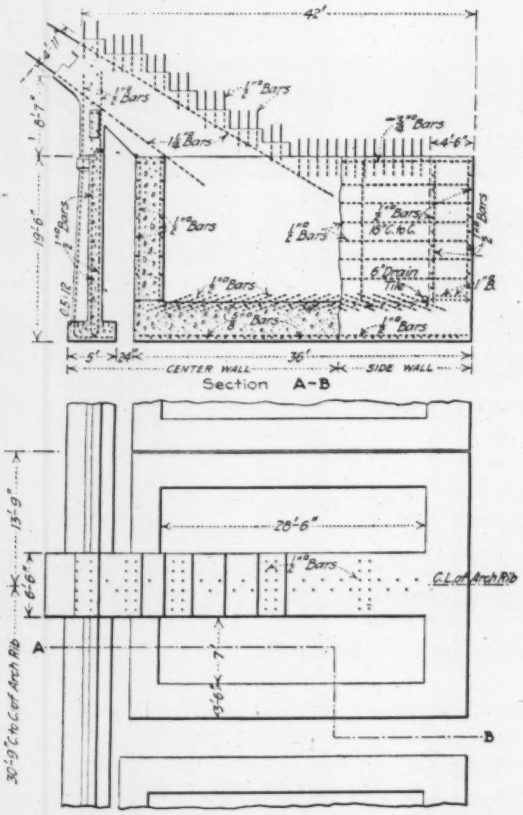


FIG. 1. EARTH-BACKED ABUTMENT, DETROIT-SUPERIOR VIADUCT

this construction, to make sure that the earth behind the abutment will be brought into action.

A. W. Zesiger, bridge engineer of Cuyahoga County, who is responsible for the design, is using similar earth-backed abutments in three other bridges which the county is now building—on South Kinsman Road, Fenkell Road and Ridge Road. The conditions in the four cases differ. The Detroit-Superior abutment, taking the thrust from a 75-ft. arch, is in hard clay, and back of it the ground rises on a hill slope 20 ft. or more. The Fenkell Road and Ridge Road bridges are smaller, and their abutments rest in and against shale. The South Kinsman Road bridge, 106-ft. span, is founded in sand (called quicksand) and has but little rise of the ground behind it; and

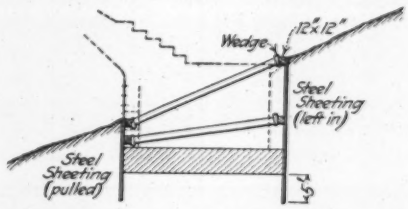


FIG. 2. SHEETING AND BRACING OF ABUTMENT PIT, DETROIT-SUPERIOR VIADUCT, EAST ABUTMENT

here some trouble was experienced in getting the abutment placed solid against undisturbed soil. This arch and two smaller ones are three-hinged, while the Detroit-Superior arch has no hinges.

The design of the Detroit-Superior abutment is shown by Fig. 1. The structure is hollow; the arch load and thrust pass through a central wall to the bottom slab and by the aid of this through central and side walls to the back slab, both slabs being reinforced to distribute their loads. The pressure allowed on the bottom is 2½ tons per sq.ft. (dead-load only); the pressure against the back slab is about half this amount. The keying of walls to bottom slab is obtained by inclined rods sloped in opposite directions in center and side walls, according to the manner of transmission of the thrust.

The pit in which the abutment is built was excavated inside a tight line of steel sheeting all round, with two sets of raking braces between front and back lines, set as the excavation went down, to prevent any give of the sheeting and hence any loosening or movement of the earth backing. When the pit was down to grade, and the bottom approved, the 4-ft. bottom-slab concrete was put in, this being below the lower braces (Fig. 2). After it had set, the lower braces were taken out and the walls concreted; the upper braces were not removed till the finished abutment was able to take the earth pressure and hold the sheeting immovable. The back line of sheeting is left in the ground. By this procedure, the engineers of the bridge believe they get full assurance that the abutment is in direct contact (through the sheeting) with undisturbed earth backing.

Abutment in Sand

The abutment of the South Kinsman Road bridge is shown by Fig. 3. The general principle of design is the same as that represented in Fig. 1. The soil is running sand, but satisfactory abutment action was expected from it. The construction work, however, is said to have let the back sheeting yield slightly, so that some caving and running took place behind it, and the main requirement on which the design is based was violated.

The county engineers solved the difficulty by increasing the crowning or rise of the arch to make up for the probable yielding of the abutment when the load thrust came against it. Their best judgment was that the abutment would move back ½ in. to 1 in., which would produce a settlement of about 6 in. at the crown of the

arch. The centers have therefore been set for an excess in rise of 9 in., allowing for 50% more than the maximum expected yielding. The hinges are expected to take up the movement without injury to the arch ring.

METHOD OF PROPORTIONING

The calculation of pressure distribution with an abutment of the type illustrated is made in consideration of the fact that the abutment is rigid and will tend to rotate

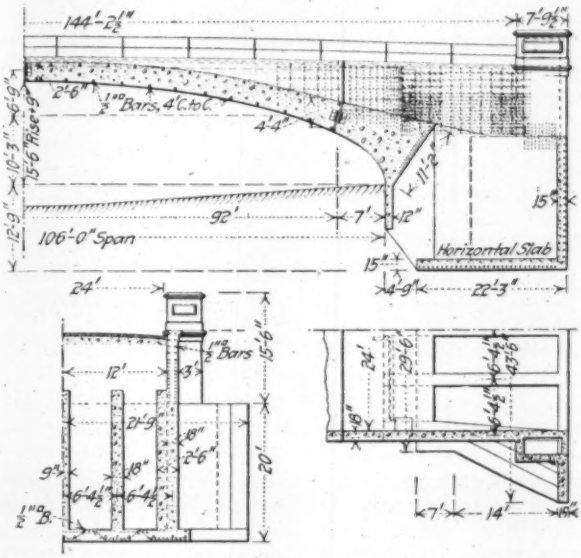


FIG. 3. ARCH AND ABUTMENT, SOUTH KINSMAN ROAD BRIDGE, CLEVELAND, OHIO

equally at bottom and back faces. With very firm soil, the elastic conditions of the backing earth may be the same as those of the soil under the bottom slab, so that, as sketched in Fig. 4, Condition A, the slope of the pressure diagram should be the same for back and bottom. In this case the overturning moment of the arch thrust, referred to the geometrical center of the rectangle, will be resisted jointly at back and bottom, in ratio of the respective section moduli.

Under other conditions, when the soil back of the abutment has less resisting power near the top than near the bottom, the effect of the abutment rotation may not

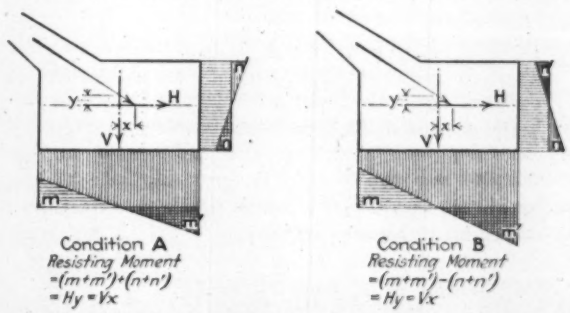


FIG. 4. EARTH-PRESSURE CONDITIONS OF ABUTMENT

give a higher pressure at the top than at the bottom edge of the back wall. But when this occurs the distribution of pressures on the bottom slab will automatically change (see Condition B in Fig. 4) to such a degree that the resisting moment of the base pressures is equal to the full overturning moment plus any moment of the back pressures in the same direction. Thus the stability of such an abutment is not dependent upon securing greater earth resistance at top than at bottom of back wall, but will tend to maintain itself by redistribution of the base pressures.

Reclamation Service Has Unique Library*

It may be of interest to engineers and other interested in irrigation to know that there has been assembled in the engineering section of the Washington office of the Reclamation Service a library of over 500 volumes of histories, specifications, engineering investigations, cost data, etc., of the various projects under construction and being operated by the Reclamation Service. Many of these volumes are in manuscript and often illustrated with photographs.

This library describes the plans leading up to the construction of irrigation works, the actual construction, the cost of the works, the settlement of project lands and operation of works. Each year reports are compiled by project managers concerning the various activities on the projects during the calendar year, chapters being written by each person in responsible charge of work, covering such subjects as clerical, fiscal, engineering, construction, drainage, operation and maintenance, lands, settlement, litigation, health and sanitation, etc. All volumes as far as possible are arranged alphabetically by state, and then by project, as follows:

Arizona, Salt River.
Montana, Huntley.
Washington, Yakima, Sunnyside unit.

A card index is also kept of volumes and contents.

In addition to these "project and feature histories" files are kept in the engineering section of the Washington office of the printed annual reports and congressional hearings having to do with the Reclamation Service, state engineers' reports, state coöperative reports, water-supply and stream-flow bulletins issued by the Geological Survey, bound volumes of the engineering periodicals and a select list of books on engineering and irrigation.

As an aid to correspondence and in order to comply with requests for information by the general public, a file is also kept in the engineering section of price lists and bulletins available for distribution, and also a subject file of information (principally engineering) which it is thought would be of interest. This file is indexed under about 50 headings, among the subjects being the following:

Abutments (standard concrete—plans), cement (standard specifications), dams (plans and specifications), dams, rolling (plans and specifications), excavation tables (handbook), farm-unit plats (price list), flumes (standard plans), gates, high-pressure (plans), hydraulic data (handbook), irrigation farming (pamphlets), land-survey notes (pamphlet), maps of national irrigation projects, pipe (wood-stave—plans and specifications), retaining walls (standard plans), sand-cement manufacture (data and cost), specifications (irrigation structures), telephone lines (cost and specifications), valves (balanced—specifications and plans), water-power development, etc.

An index list of all engineering articles by engineers of the Service and of articles on the work of the Service by other writers is maintained and published at intervals for reference.

*From "Reclamation Record," U. S. Reclamation Service, September, 1915.

Engineering Literature

Bibliography of Engineering Literature--A Beginning

The Library of the Engineering Societies, New York City, has begun a highly commendable work in compiling a bibliography of engineering literature. Of the need of such a bibliography there is no question, as has been often noted in these columns, and it is with pleasure that we are able to announce the publication of the Library's Bibliographical Contribution No. 1, entitled "Catalogue on Technical Periodicals in the Libraries of the City of New York and Vicinity," compiled and edited by the assistant librarian, Alice Jane Gates.

Seven libraries are included in this catalog: Columbia University, Chemists' Club, American Society of Civil Engineers, Engineering Societies, New York Public Library, Plainfield (N. J.) Public Library and Stevens Institute of Technology.

Scientific and engineering periodicals dating back to the beginning of the *Transactions* of the Royal Society of London in 1665 contain a great share of the original contributions to practical science, out of which many tomes have been built, and to the searcher of historical lore these old periodicals are mines of information. The modern periodicals, of course, are of practical everyday use; and this bibliography will be an exceedingly useful tool in the office of any engineer who has access to one or all of the libraries listed. It is hoped eventually to extend the list to other engineering libraries throughout the country.

The book has 128 pages and contains about 2,600 entries, of which the following is typical:

Eclairage électrique. W. Vol. 1-53. September 1894-December 1907. Par., 1894-1907.
Known as La lumière électrique from April 1879-August 1894 and 1908 to date.
Tables générales. Vol. 1-10. 1894-1897 In Vol. 10. N.p., 1883.
Tables générales. Vol. 1-25. 1894-1900. Par., 1902.
E. 1-53; **N.** 1-53; **CC.** 1-21.

It is published by the Library Board of the United Engineering Society, 29 West 39th St., New York City, at the price of $2.50 in paper and $3 in cloth.

CORRESPONDENCE

Direct-Acting Steam Pumps

Sir—Some amazing statements contained in H. E. Longwell's review of my book on "Direct-Acting Steam Pumps" in your issue of Sept. 16, 1915, should not remain unanswered. The opening paragraph was, no doubt, written from the standpoint of a centrifugal-pump man. A visit to our shops at Harrison, N. J., will convince anybody that the direct-acting pump is still very much alive and promises to be with us for some time to come. It supplies a field that the centrifugal pump can never hope to conquer.

The theory always follows the practice, and it can also be said that no such theory of the steam engine as is now used to the greatest advantage existed in the mind of Watt. If the successors did follow the lead of the pioneers blindly, the writer was not one of them. He early recognized the defects of the rules of thumb that were in use for calculating sizes and duties and developed rational methods for arriving at these values.

I agree with the statement that the table of boiler-feed pumps is not as it should be. The ratio should be uniform or should decrease (not increase as was printed) in the larger sizes. A new table calculated according to this idea would, however, be of no value. The table as given represents the sizes in actual use. H. R. Worthington often said that, had he known that every pump builder in the country was going to copy his sizes, he would have used more care in their selection. The ratios are also influenced largely by commercial reasons and the engineer is often defeated by the sales department.

In making the illustrations for single pumps, I followed the method of the designer, who always places piston and valves in a central position. Much may be said for or against this method.

How anybody can proclaim the tables of steam forces of doubtful value passes my conception. The constant demand for a set of these tables proves that they must be of value to somebody.

The remark that the duty of a direct-acting steam pump is pretty much of a joke is also beyond me. It is certainly no joke to the pump manufacturer, who must daily guarantee duties for "tiny simple pumps" as well as for large pumps. Frequently, other considerations than the saving of coal demand that the steam consumption be calculated closely. Foremost of all is the boiler power, since the boiler must be large enough to run the tiny pumps as well as the large ones. This chapter is the result of long and painstaking research. I could have filled several pages of the book with actual test results, giving those usual readings, most of which are of no value, for the determination of the duty that can be guaranteed on some other engine running under different conditions. Numerous tests were investigated and tabulated. From these the average losses were determined and formulas devised; the tables were then calculated by these formulas and have so far proven reliable. In the light of later experience they may be recalculated, and any suggestions are welcome. The greatest value of these tables is that they afford a means to the manufacturer to be consistent in his guaranties.

F. F. NICKEL.

East Orange, N. J., Sept. 25, 1915.

[Mr. Longwell submits the following reply to Mr. Nickel's letter.—Editor.]

Sir—To the charge of being a "centrifugal-pump man" I respectfully plead not guilty. On the contrary, a good many years ago, in the self-confidence of youth, I had the temerity to believe that I was fairly well experienced in the design and construction of the type of pump that is the subject of Mr. Nickel's book.

The statement that a machine "has ceased to be of much general interest from an engineering standpoint" does not necessarily imply that it is commercially dead. The ordinary slide-valve throttling engine is still manufactured and sold extensively, and promises to be with us for some time to come, and yet no one would seriously contend that it is a subject of much general interest from an engineering standpoint.

When a device has shown no material development in a quarter of a century, and admitted inconsistencies in its design have remained uncorrected, we may fairly regard it as something that the public may accept as a useful—perhaps indispensable—implement, without being interested in the engineering principles involved.

The demand for copies of the tables of steam forces is hardly a proof of their value. Many people are afflicted with all-devouring and indiscriminating appetites for data sheets of all sorts, irrespective of whether they will in any degree contribute to their welfare or happiness.

Possibly the duty of an engine that may consume from 100 to 200 lb. or more of steam per horsepower-hour is not a joke; perhaps it is a tragedy. It may be that the duty tables are reliable, in spite of the fact that they appear to be inconsistent in some respects. They undoubtedly represent a great deal of hard work on the part of the author. In dealing with efficiencies, however, it is usually more satisfactory to give a reasonable selection of actual tests, with the essential data, so that the reader may have some opportunity for the exercise of his own intelligence, and not have to undergo the humiliation of being spoon-fed with the results of someone else's interpretation and rationalization of the tests. As the author states in his work that "the duty guaranteed by the manufacturer is not the everyday duty," perhaps a few examples of "everyday duties" might be more illuminating than a larger number of estimated duties. It is hardly flattering to the reader to suggest that it is useless to present the actual tests, for the reason that he could not be expected to make intelligent use of them.

Engineers are a trifle prone to give too much weight to thermal efficiency and too little to commercial efficiency. These two efficiencies are not always compatible, and the former may often be sacrificed with advantage in favor of the latter. The direct-acting steam pump is a striking example of an engine of peculiarly atrocious thermal efficiency, which for many kinds of service is commercially efficient to a degree that, as yet, has not been equaled.

I trust that the foregoing paragraph will clear me of the implication that my contribution to your issue of Sept. 16 was an attack on an important industry, masquerading as a review of a technical book.

H. E. Longwell.

New Haven, Conn., Oct. 5, 1915.

Faults in Technical Literature

Sir—The article by R. Fleming, entitled "Faults in Technical Literature," published in *Engineering News* of Sept. 16, 1915, should be reprinted in the various library publications, as the question of faulty technical literature is at least of as much importance to the library as to the engineer.

Aside from the prime importance of the standard of a given publication, there are certain other fundamental facts to be considered when a library purchases a technical book. The sequence of importance is not easily determined. However, as a library exists for its card holders and other users, it may be well to look at that side of the question first.

A publication is bought and placed on the shelves of a library and is then available to numerous users; whereas, when put in the library of an engineer the use of the same publication rarely extends farther than to the engineer or his immediate associates. Take as a concrete example Ketchum's recent "The Structural Engineer's Handbook." This book has already gone through the hands of eleven people here, and twice to another library where still other persons consulted it. While without doubt the general excellence of this book is not to be questioned, the fact remains that if formulas are incorrect the number of chances for working harm are multiplied every time the book leaves the library or is consulted within the library.

Technical books depreciate in value in proportion to the importance of the particular branch of engineering treated, or its future. The librarian has to make allowance for this, since the books on his shelves are his stock in trade.

Technical journals are making long steps in the matter of guiding the would-be purchaser of the present-day publications. The librarian looks forward to a still more active censorship of technical productions. Meanwhile he agrees with Mr. Fleming that "technical literature never was better than it is today."

Kenneth C. Walker,
Head Department of Technology.

Public Library, New Haven, Conn., Sept. 23, 1915.

Sir—My attention has been called several times to an error in the correction of an error in my article, "Faults of Technical Literature," appearing in *Engineering News* of Sept. 16, page 548. The beam of the "American Civil Engineers' Pocket Book" there considered is fixed at one end, supported at the other and uniformly loaded, instead of being a cantilever beam uniformly loaded. In the formula small w should replace large W, so that the correct bending moment should read:

$$M = \frac{wlx}{2}\left(\frac{3}{2} - \frac{x}{l}\right)$$

The error in the article is my own fault, and while I have been reminded that "people in glass houses must not throw stones," it is hoped that the glass will at an early date be replaced by stone walls.

R. Fleming,
American Bridge Co.

30 Church St., New York, Sept. 30, 1915.

[A number of correspondents have called attention to the error which Mr. Fleming acknowledges in the foregoing letter. Their comments, as well as those by Mr. Walker on this page, reinforce Mr. Fleming's remarks in *Engineering News* of Sept. 16 as to the importance of accuracy in technical literature. Some of the letters of correction express appreciation of the difficulties to be met by both authors and publishers in securing accuracy—a difficulty which Mr. Fleming himself pointed out in his original contribution, but which only those who have experienced it to their own discomfiture and regret can understand.—Editor.]

REVIEWS AND NOTES

All About Grinding

REVIEWED BY RALPH E. FLANDERS*

GRINDING MACHINERY—By James J. Guest. New York: Longmans, Green & Co.; London: Edward Arnold. Cloth; 6x9 in.; pp. xi+444; 200 illustrations. $4.20 net.

There have been many good technical books published in this country and many poor ones published abroad. It is yet true that foreign technical books average somewhat higher in useful qualities than American ones—at least in the field of mechanical engineering, with which the reviewer is most familiar. The book under review is written by an Englishman. In lack of padding, breadth of knowledge and originality of material it measures up to the best standards of technical bookmaking.

The examples of mechanism and methods are drawn freely from the practice of England, Germany and particularly the United States, so that it is not handicapped for American use by its foreign origin.

The most interesting section of the book is that in which the author develops his theory that the controlling factor in grinding may be expressed as

$$V^2 \frac{d+D}{dD} t,$$

in which V is the surface velocity of the work, D and d the diameter of the wheel and work respectively, and t the diametrical reduction of the cut. When this factor falls below a certain amount the wheel glazes. When it rises above a certain other, large amount, the wheel disintegrates too rapidly. This theory leads to a somewhat different range of work speeds than has been common in most shops, but the writer brings good evidence to prove that the theory holds good in practice.

Machine grinding is too often considered a matter of mystery and blind empiricism. Mr. Guest's book gives information which will turn much of the grinding man's mystery into clear understanding.

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OFFICIAL HANDBOOK OF THE PANAMA CANAL, 1915—Washington, D. C.: Office of the Isthmian Canal Commission. Paper; 6x9 in.; pp. 58; illustrated.

While the Panama Canal was under construction, several editions of an official handbook were issued for distribution to visitors and others, giving the principal facts of popular interest concerning the canal. These books have now been superseded by the new official publication, which deals with the completed canal. It gives tables of distances saved in trade routes by the use of the canal, describes how a vessel is handled through the canal, facilities for shipping, the saving in cost by use of the canal, the manner in which tolls are computed and a brief description of some of the principal features along the line of the canal. An interesting comparison is given of the volume of freight which passed through the canal in the first year of its operation and the traffic that would be required on a railway to pass the same amount of freight. The average freight-train load on the Panama R.R. is about 350 tons. To have carried on the railway the freight that passed through the canal last year would have required the dispatching of 39 trains a day throughout the year.

*Manager, Jones & Lamson Machine Co., Springfield, Vt.

American Travel Illustrated

A HISTORY OF TRAVEL IN AMERICA: Showing the Development of Travel and Transportation from the Crude Methods of the Canoe and the Dog-Sled to the Highly Organized Railway Systems of the Present, Together with a Narrative of the Human Experiences and Changing Social Conditions That Accompanied This Economic Conquest of the Continent—By Seymour Dunbar. (In four volumes.) Indianapolis, Ind.: The Bobbs-Merrill Co. Cloth; 6x9 in.; pp. 1529; 400 illustrations and numerous colored plates. $10, net.

Save for the illustrations and a few pages of text, this work is a history of travel rather than of transportation methods. Steamboat navigation, however, is covered fully and authoritatively and in the section on early railways there are a few pages on track construction. The details of railway facilities and operating methods gleaned from contemporary literature and a host of interesting illustrations make the material both interesting and valuable.

The part that trails, roads, rivers and canals played in the early migrations of Americans is interestingly and completely told. Although the early travel routes and methods of travel between the principal points of the East are described in some detail, the main theme of the history is the steady and never-halting expansion of the population to the westward. Many and all kinds of books have been written of this remarkable achievement of the American people, but this history concerns itself mainly with personal reminiscences of various pioneers and some account of the vehicles and means by which they accomplished their journeys—on foot over trails, with pack trains, wagon trains, stage coach, flatboat, keel-boat, barge, canal boat, steamboat and steam locomotive. It is much more than a history of travel, for it deals comprehensively and intimately with many phases of American life and character that contributed materially to the rapid settlement and development of a great continent.

The author deserves great credit for the bibliography and many annotations the book contains. These, with the 400 illustrations reproduced from many sources unavailable to the general reader, make the four volumes valuable to one interested in engineering history. It is regrettable, however, that more mention is not made of the lives, work and achievements of the early American engineers, for this would have enchanced its value to engineer readers without detracting at all from its interest to the general public.

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SURVEYING MANUAL: A Manual of Field and Office Methods for the Use of Students in Surveying—By William D. Pence, M. Am. Soc. C. E., Professor of Railway Engineering, University of Wisconsin, and Milo S. Ketchum, M. Am. Soc. C. E., Dean, College of Engineering and Professor of Civil Engineering, University of Colorado. Fourth Edition. New York and London: McGraw-Hill Book Co., Inc. Flexible leather; 4x7 in.; pp. xiv + 388; illustrated. $2, net.

This is the fourth edition of one of the earliest and best student's surveying manuals. The authors state that the book has been revised, nearly all the cuts redrawn, tables added and the entire text reset. The distinguishing characteristics of the book, the most notable of which, perhaps, is the great variety of problems, have been retained. The many pages of sample field notes and the clear-cut, practical directions for solving many of the problems that are continually occurring in every surveyor's practice have made this manual one of the most popular of its kind. It contains a great many kinks and short cuts in surveying practice that, so far as the reviewer knows, are not found in any other textbook.

Fluid Friction Explained

REVIEWED BY ROBERT E. HORTON*

MOTION OF LIQUIDS—By Lieut.-Col. R. De Villamil. New York: Spon & Chamberlain. London: E. & F. N. Spon, Ltd. Cloth; 6x9 in.; pp. xiv + 210; 86 illustrations and 30 tables. $2.50.

This is not a treatise on the flow of water in the ordinary sense. It does not contain the usual working formulas for engineers, nor tables of coefficients, friction losses or the like.

The book is dedicated to Chevalier Col. W. A. Dubuat and to Col. Duchemin. De Villamil states that Dubuat's work is unfortunately much neglected and that Duchemin's remarkable book on the "Laws of Resistance of Fluids" is almost unknown in England. From the preface it appears that part of Dubuat's experimental work in hydraulics has not been generally accepted, for the reason that it was thought to contain an inconsistency known as "Dubuat's Paradox."

Upon reading the first few chapters of the book, one gets the impression that the object of the author is chiefly to explain the so-called "paradox" of Dubuat; to show that it is consistent with the principles of the resistance of motion of liquids which are revealed in practice in a number of ways, but which have not generally been recognized, and that therefore it is not a paradox; and also to restore to Dubuat the full measure of credit as an experimenter and original discoverer to which he is properly entitled, and in like manner to introduce in English the work of Duchemin, who repeated Dubuat's experiments 50 years later, with results similar to those obtained by Dubuat. On further reading it appears that the attainment of the object stated does not cover the full scope of the book. The author says, on p. 114: "Most unfortunately, in hydrodynamics there is hardly a statement which can be made that is absolutely true in all cases." De Villamil's book deals with the exceptions, he having set forth the established principles of fluid motion in his previous work entitled "A. B. C. of Hydrodynamics." In dealing with the exceptional occurrences in the motion of fluids, the whole treatment by De Villamil centers around the question of the difference in the resistance between a solid and a fluid when either one is moving relatively to the other, according as the fluid is static or not. De Villamil takes the position that there is a difference in the two cases and that this difference is due to the existence of internal motion other than inter-molecular motion. To begin with, he defines a statical liquid as distinguished from one that is nonstatical. The definition he gives, like a number of others throughout the book, seems somewhat labored and more elementary than necessary to meet the intelligence of the class of readers to whom De Villamil's book would be of interest.

Three independent branches of hydraulic investigation have grown up and workers in one field know but little of the results or theories used in the other two fields. The three branches include hydrodynamics, as a branch of mathematical physics, naval hydromechanics and ordinary engineering hydraulics. In his former book on hydrodynamics, De Villamil presented in clear nonmathematical form a digest and correlation of the results attained by investigators of similar subjects in the three different fields, and viewing the subjects from different angles. The same policy is pursued, though in a lesser degree, in the present work, in that illustrations and formulas drawn from aërodynamics are sometimes used in support of De Villamil's contentions regarding fluid friction. A number of illustrations are produced in support of the proposition that, with some limitations, when a fluid or liquid flows alongside a nonwetted solid surface eddies are formed between the liquid or fluid and the surface and in some way part of the energy of position used to generate the eddies or vortices is converted back into energy of motion and aids to increase the discharge or flow through an orifice, or to reduce the friction in the case of motion of a solid in a liquid or fluid. De Villamil points out the conditions under which this phenomenon may occur, and since it was first, or at least most specifically, noticed in studies of the resistance to the motion of solids in fluids, it acquired the most particularly unfortunate designation of negative resistance.

On reading the preceding statement one might gain the impression that De Villamil's book is hypertechnical and speculative. That is not, however, the case, except to the limited degree to which suggestions and hypotheses must almost invariably precede the formulation of a true explanation of obscure phenomena. Quite probably De Villamil has been over-enthusiastic in citing illustrations of the occurrence of negative resistance, so called. Some of the illustrations which he cites, such as that of corrasion below a waterfall, or increase in discharge of weirs when the volume of air underneath the nappe is reduced or eliminated, do not appear to the writer to be illustrations of the phenomenon of eddy formation which occasions the transfer of energy described as negative resistance, but are probably due to entirely different causes. One should read De Villamil's book with his mind open and alert.

De Villamil states that Riabouchinsky has agreed to repeat both Dubuat's and Duchemin's experiments at Koutchino. One feels distinct regret that this had not been done at the time the book was written and a number of other simple experiments suggested by the author performed in addition thereto.

There are many books which give the data of fluid friction, but there is perhaps none which goes so nearly to the foundation of explaining the causes of the phenomena as do the two books of De Villamil. "Motion of Fluids" is a book which should be read by engineers who wish to understand as well as to know the facts of hydraulics. It is by no means as satisfying a book as its predecessor on hydrodynamics and leaves one with the feeling that much more could have been accomplished with a few additional experiments and more mature study.

PURCHASING—By C. S. Rindsfoos, C. E., President of the United States Purchasing Corporation; former Secretary-Treasurer, The Foundation Company. New York and London: McGraw-Hill Book Co., Inc. Cloth; 6x9 in.; pp. x + 165. $2, net.

The personality necessary in a first-class buyer or salesman cannot be acquired by reading or study. The technique of buying or selling, however, can be learned. This is what this book endeavors to teach. The chapter on "Strategy" is of especial interest, although it portrays those methods and coups which are well known to most salesmen and buyers. Although written from the standpoint of the purchaser, the seller who needs to know his "enemy's" methods will probably recognize several schemes that have been tried on him in the past.

*Consulting Hydraulic Engineer, 57 N. Pine Ave., Albany, N. Y.

The chapter on the legal aspects of purchasing contains some important information. The book should appeal not only to buyers and salesmen, but to their employers as well.

Lighting Store Windows

DISPLAY WINDOW LIGHTING AND THE CITY BEAUTIFUL: Facts and New Ideas for Progressive Merchants—By F. Laurent Godinez, Consulting Lighting Specialist; Member, Jersey City Chamber of Commerce; author of "The Lighting Book," "What Do We Know About Lighting?" "Light on Decoration," etc. New York: The Wm. T. Comstock Co. Cloth; 6x9 in.; pp. 222; 114 illustrations. $2, net.

The author has continued in a new volume his previous attacks on commercialized illuminating engineering and "art" as exemplified by the random and indiscriminate use of prismatic-glass shades and globes. In spite of a general improvement of lighting effects observable throughout the country, there is much left to be censured—as this book shows anyone who has not independently observed it.

Great white ways are severely condemned as glaring, unartistic and horribly monotonous. The consequent argument is to place municipal-lighting problems in the hands of a competent group of architects and lighting specialists (not the illuminating engineers who have as a profession, according to the author, become commercialized and gone to seed). The author is the foe of glare and garishness, particularly in store-display lighting. He would conceal his light sources entirely from the passerby and induce softness of illumination through opaque diffuse shades and reflectors in place of the translucent- or prismatic-glass variety which has become so popular. A silver-backed opalescent glass is the material preferred.

Separate chapters take up the problems peculiar to gas and electric lighting, with examples of each. One chapter is devoted to sign lighting—giving good and bad examples.

In a chapter on color attraction the author pleads for the wider use of amber filters and a reduction in the use of white light. There is some general information on various color effects that can be produced easily and economically.

One section of the book takes up in interesting fashion the better window-lighting campaign in Jersey City carried out under the author's direction by the Chamber of Commerce and the lighting company of that city.

PLAIN TALK: Economies, Gas Works, Pigeons, Good Roads, Sign Boards, Garbage, City Plan, Graft, Marketing, Public Singing, Drinking Water, Street Cleaning, Bridges, Contracts, Band Music, Public Utilities, Street Lighting, Water Waste and Other Things of General Interest—A Report by Morris Llewellyn Cooke, Director of the Department of Public Works, Philadelphia, Penn. Paper; 6x9 in.; pp., 108; illustrated. Copies may be had without charge on application to Room 216, City Hall, Philadelphia.

A most unusual report—as intended. The high points in the work of the year, particularly those most likely to appeal to the intelligent and righteous citizen, are treated interestingly. At the same time a general idea of the work, but more particularly of the spirit of the work, of the department in 1914 and the two earlier years of the present administration, is given. For comprehensive details of the year's work the searcher for information will turn to the reports of the several bureaus of the department, some of which are already available in separate form. The present report goes much farther in booming the administration of the government of Philadelphia under Mayor Blankenburg than one would wish to see in municipal reports generally; but the case of "corrupt and contented" Philadelphia is a desperate one, demanding radical treatment.

NEW PUBLICATIONS

[So far as possible the name of each publisher of books or pamphlets listed in these columns is given in each entry. If the book or pamphlet is for sale and the price is known by the editor, the price is stated in each entry. Where no price is given it does not necessarily follow that the book or pamphlet can be obtained without cost. Many, but not all, of the pamphlets, however, can be secured without cost, at least by inclosing postage. Persons who are in doubt as to the means to be pursued to obtain copies of the publications listed in these columns should apply for information to the stated publisher, or in case of books or papers privately printed, then to the author or other person indicated in the notice.]

THE ABOLITION OF POVERTY—By Edwin Jennings. New York City (142 West 82nd St.): The Author. Paper, 5x7 in.; pp. 31. 25c.

A socio-religious tract by a civil engineer.

ALTERNATING-CURRENT WORK: An Introductory Book for Engineers and Students—By W. Perren Maycock, M. Inst. E. E.; Consulting Electrical Engineer; late Technical Editor to the Westinghouse Companies' Publishing Department in Europe. An enlargement of and an improvement upon the author's former work, "The Alternating-Current Circuit and Motor." New York: The Macmillan Co. London: Whittaker & Co. Cloth; 5x8 in.; pp. xxiii + 415; 258 illustrations. $2.25.

ANNUAL REPORT OF THE TRAINING SCHOOL FOR PUBLIC SERVICE 1914-15—Conducted by the Bureau of Municipal Research, 261 Broadway, New York City. Paper; 6x9 in.; pp. 30.

BOSTON STATISTICS, 1915—Boston, Mass.: City Statistics Department. Paper; 3x6 in.; pp. 25.

THE CALLENDAR STEAM TABLES—By H. L. Callendar, Professor of Physics in the Imperial College of Science and Technology, South Kensington; author of the "The Properties of Steam." New York: Longmans, Green & Co. London: Edward Arnold. Cloth; 6x9 in.; pp. 40. Steam diagram in pocket. 80c.

CATSKILL WATER SUPPLY: A General Description—Board of Water Supply of the City of New York, Municipal Building, New York City. Paper; 6x9 in.; pp. 39.

A new and uptodate edition of a handy and much appreciated description of this great engineering work.

CONCRETE SEPTIC TANKS for Farmhouses and Dwellings in Small Towns—Prepared and published by the Universal Portland Cement Co., Chicago, Ill. Paper; 6x9 in.; pp. 8; illustrated.

Considering its size, this pamphlet contains much misinformation on septic tanks as means of sewage treatment and a considerable amount of useful information on septic tanks, filter beds, etc., as structures. Even the latter is likely to mislead when put in the hands of the farmer or the village householder. If the pamphlet were revised by a competent sewage-works engineer it might promote sound rural sanitation, as well as the sale of cement.

CONFERENCE OF BUILDING INSPECTORS AND BUILDING COMMISSIONERS OF THE UNITED STATES AND DOMINION OF CANADA, Held at New York City, May 14, 1915. Brooklyn, N. Y. (1973 E. 14th St.): J. G. Needham, Official Stenographer. Paper; 8x11 in.; pp. 115. $4.

THE DEVELOPMENT OF THE NEW BEDFORD WATER-SUPPLIES—By Robert C. P. Coggeshall. Old Dartmouth Historical Sketches No. 42 (being the proceedings of the Old Dartmouth Historical Society, held in its building, Water St., New Bedford, Mass., on Apr. 19, 1915). Paper; 7x10 in.; pp. 23.

A detailed sketch, covering a century and more, by the long-time and present superintendent of the New Bedford water-works.

DISPOSAL OF THE SEWAGE AND PROTECTION OF THE WATER-SUPPLY OF CHICAGO, ILL.—A Report to the Chicago Real Estate Board by George A. Soper, John D. Watson and Arthur J. Martin. Chicago: The Board. Cloth; 6x9 in.; pp. 212.

The main conclusions of this interesting report were noted on page 1169 of "Engineering News" of June 17, 1915. The report itself has only now become available.

EFFECTIVE BUSINESS LETTERS: Their Requirements and Preparation, with Specific Directions for the Various Types of Letters Commonly Used in Business—By Edward Hall Gardner, Assistant Professor of English in the University of Wisconsin. Cloth; 5x8 in.; pp. xii + 376. $2 postpaid.

THE ELECTRIC RAILWAY—By A. Morris Buck, Assistant Professor of Railway Electrical Engineering, University of Illinois. New York and London: McGraw-Hill Book Co., Inc. Cloth; 6x9 in.; pp. xi + 390; 193 illustrations. $3 net.

ELEMENTARY ALGEBRA—By Florian Cajori, Colorado College, and Letitia R. Odell, North Side High School, Denver. (First-Year Course.) New York: The Macmillan Company. Cloth, 5x8 in.; pp. vii + 206; 37 illustrations. 65c.

ELEMENTS OF RAILROAD TRACK AND CONSTRUCTION—By Winter L. Wilson, Professor of Railroad Engineering, Lehigh University. Second edition, revised and enlarged. New York: John Wiley & Sons, Inc. London: Chapman & Hall, Ltd. Cloth; 5x8 in.; pp. vi + 396; 210 illustrations. $2.50 net.

EXAMPLES IN ALTERNATING CURRENTS, Vol. I: For Students and Engineers—By F. E. Austin, Professor of Civil Engineering, Thayer School of Civil Engineering, Dartmouth College; author of "How to Make a Transformer for Low Pressures," "How to Design, Make and Operate High-Pressure Transformers," "Examples in Magnetism." Hanover, N. H.: The Author, P. O. Box 441. Flexible leather; 5x8 in.; pp. 223; 70 illustrations. $2.40 postpaid.

FARM WATER-SUPPLIES—Minnesota State Board of Health (Division of Sanitation), Minneapolis, Minn. Paper; 6x9 in.; pp. 29; illustrated.

FIELD ENGINEERING: A Handbook of the Theory and Practice of Railway Surveying, Location and Construction—By William H. Searles, M. Am. Soc. C. E. 17th edition, revised and enlarged by William H. Searles and Howard Chapin Ives, Professor of Railroad Engineering in the Worcester Polytechnic Institute. New York: John Wiley & Sons, Inc. London: Chapman & Hall, Ltd. Flexible leather; 4x7 in. Vol. I, text; pp. xvii + 309; 148 illustrations. Vol. II, tables; pp. vi + 323. Bound in one volume, $3 net; bound separately, $2 net each.

THE FLOW OF WATER IN IRRIGATION CHANNELS—By Fred C. Scobey, Irrigation Engineer. Bulletin No. 194, U. S. Department of Agriculture. Washington, D. C. (Government Printing Office): Superintendent of Documents. Paper; 6x9 in.; pp. 68; illustrated. 25c.

The author says that this bulletin is based on field tests made for the purpose of determining the retardation factor in Kutter's formula under the various conditions found in practice.

GUIDEBOOK OF THE WESTERN UNITED STATES—Washington, D. C.: (Government Printing Office): Superintendent of Documents. Paper; 6x9 in.; illustrated. Part C: The Santa Fé Route, with a Side Trip to the Grand Canyon of the Colorado—By N. H. Darton and Others. Bulletin 613. Pp. 194. Part D: The Shasta Route and Coast Line—By J. S. Diller and Others. Bulletin 614. Pp. 142.

These complete the set of four volumes of the guidebook. Parts A and B, covering the Northern Pacific and the Overland Routes, with a side trip to Yellowstone Park, were noted in "Engineering News" of Aug. 19, 1915, p. 361. The parts are $1 each.

HANDBOOK OF MATHEMATICS FOR ENGINEERS—By L. A. Waterbury, M. Am. Soc. C. E.; Professor of Civil Engineering, University of Arizona. Second edition. New YORK (29 West 39th St.): Proceedings for 1914. Cloth; Hall, Ltd. Flexible leather; 3x6 in.; pp. xii + 213; 80 illustrations. $1.50 net.

IOWA STATE DRAINAGE ASSOCIATION: Proceedings of Annual Meeting Held at Webster City, Ia., Feb. 25 and 26, 1915. Ames, Ia.: M. F. P. Costelloe, Secretary. Paper; 6x9 in.; pp. 111. 25c. prepaid.

THE JOURNAL OF THE IRON AND STEEL INSTITUTE, Vol. XCI—London (28 Victoria St., S. W.): George C. Lloyd, Secretary. Cloth; 6x9 in.; pp. 711.

LOCATION OF IGNITION SYSTEM TROUBLES MADE EASY: A Chart Giving a Concise Exposition of the Common Derangements That Interfere with Efficient Operation of Internal Combustion Motor Ignition Systems—Arranged by Victor W. Page, author of "The Modern Gasoline Automobile." New York: The Norman W. Henley Publishing Co. Paper; 22x34 in. 25c.

MECHANICAL DRAWING, with Special Reference to the Needs of Mining Students—By Joseph Husband, Assoc. M. Inst. C. E.; Head of the Civil Engineering Department of the University of Sheffield. New York: Longmans, Green & Co. London: Edward Arnold. Paper; 8x11 in.; pp. 79; 230 illustrations. 80c. net.

THE MODERN AUTOMOBILE: Its Design, Construction, Maintenance and Repair—By Victor W. Page, late Technical Editor of "The Automobile Journal," author of "The Modern Gas Tractor" and "Automobile Questions and Answers." 1916 Revised Edition. New York: The Norman W. Henley Publishing Co. Cloth; 5x8 in.; pp. 871; 575 illustrations and diagrams. $2.50.

THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK. (29 West 39th St.): Proceedings for 1914. Cloth; 6x9 in.; pp. 544.

NEW JERSEY BOARD OF PUBLIC UTILITY COMMISSIONERS (Trenton, N. J.)—Financial and Miscellaneous Statistics Compiled from the Annual Reports Made by Public Utilities, 1913. Paper; 6x9 in.; pp. 400.

PRINCIPLES OF DIRECT-CURRENT MACHINES—By Alexander S. Langsdorf, F. Am. Inst. E. E., Professor of Electrical Engineering and Dean of the Schools of Engineering and Architecture, Washington University. [Electrical Engineering Texts]. New York and London: McGraw-Hill Book Co., Inc. Cloth; 6x9 in.; pp. xxiii + 404; 313 illustrations. $3 net.

REPORT OF THE SECOND INTERSTATE CONFERENCE (OF AUSTRALIA) ON ARTESIAN WATER, 1914—Brisbane: J. E. Slade, Secretary. Cardboard; 8x13 in.; pp. 295; illustrated.

REPORT OF THE WATUPPA PONDS AND QUEQUECHAN RIVER COMMISSION to the City Council, City of Fall River, Mass., Together with the Report of Fay, Spofford and Thorndike, Consulting Engineers. Fall River: The Commission. Cloth; 6x9 in.; pp. 203; illustrated.

An interesting and suggestive report on an unusual combined water-works, water-power, condensing water, storm-water and sewage-disposal project.

RESULTS OF EXPERIMENTS ON SEWER PIPE AND DRAIN TILE—By E. H. Beckstrand, Professor of Mechanical Engineering. Bulletin No. 7, Utah Engineering Experiment Station, June, 1915. Salt Lake City, Utah: State School of Mines, University of Utah. Paper; 6x9 in.; pp. 52; illustrated.

External and internal breaking tests, absorption and other tests, made from 1912 to 1915, chiefly on clay and concrete tile and sewer pipe from 3 to 30 in. in diameter, manufactured in Utah and adjoining states, but including some large 36- to 60-in. reinforced-concrete pipe made in Chicago.

SEWAGE TREATMENT EXPERIMENTAL PLANT IN BROOKLYN, N. Y.—By George T. Hammond, Engineer in Charge for the Department of Sewers, Borough of Brooklyn, New York City. [Reprinted from the Proceedings of the American Society of Municipal Improvements.] Paper; 6x9 in.; pp. 42; 31 illustrations.

STANDARDS OF SERVICE FOR WATER COMPANIES—Established by the State Public Utilities Commission of Illinois, Springfield, Ill. Paper; 6x9 in.; pp. 7.

STATISTICS OF RAILWAYS, 1904-1914, UNITED STATES—Washington, D. C.: Bureau of Railway Economics. Paper; 6x9 in.; pp. 67.

Based on annual reports of the Interstate Commerce Commission and the Bureau of the Census.

STEAM-BOILER ECONOMY: A Treatise on the Theory and Practice of Fuel Economy in the Operation of Steam-Boilers—By William Kent, author of the "Mechanical Engineer's Pocket-Book." Second edition, revised and enlarged. New York: John Wiley & Sons, Inc. London: Chapman & Hall, Ltd. Cloth; 6x9 in.; pp. xvii + 717; 244 illustrations. $4.50, net.

STEAM POWER—By W. E. Dalby, M. Inst. C. E., London University Professor of Engineering at the City and Guilds Engineering College of the Imperial College of Science and Technology. New York: Longmans, Green & Co. London: Edward Arnold. Cloth; 6x10 in.; pp. xvi + 760; 250 diagrams. $6 net.

TECHNOLOGIC PAPERS, UNITED STATES BUREAU OF STANDARDS—Washington, D. C. (Government Printing Office): Superintendent of Documents. Paper; 7x10 in.; illustrated.

No. 44: Investigation of the Durability of Cement Drain Tile in Alkali Soils (Containing Results of First Year's Tests)—By R. J. Wig, Engineer Physicist, and G. M. Williams, Assistant Engineer Physicist, in co-operation with S. H. McCrory, Chief of Drainage Investigations, Department of Agriculture; E. C. Bebb, Engineer, United State Reclamation Service, and L. R. Ferguson, Assistant Secretary of the Association of American Portland Cement Manufacturers. Pp. 56.

No. 47: Value of the High-Pressure Steam Test of Portland Cements—By R. J. Wig and H. A. Davis, Assistant Engineer Physicist. Pp. 34.

No. 48: An Air Analyzer for Determining the Fineness of Cement—By J. C. Pearson, Assistant Physicist, and W. H. Sligh, Aid. Pp. 74.

No. 55: Measurements for the Household. (Circular). Pp. 149.

TELEPHONE APPRAISAL PRACTICE—By J. C. Slippy, author of "Telephone Cables" and "Appendix A, Telephone Construction-Methods and Costs." Pittsburgh, Penn. (428 Oliver Building): The Author. Cloth; 6x9 in.; pp. 97. $4.

A TEXTBOOK ON PRACTICAL MATHEMATICS FOR ADVANCED TECHNICAL STUDENTS—By H. Leslie Mann, Lecturer in Advanced Practical Mathematics, The Woolwich Polytechnic. New York and London: Longmans, Green & Co. Cloth; 6x9 in.; pp. xi + 487; 149 illustrations. $2.10 net.

TRAMWAY TRACK CONSTRUCTION AND MAINTENANCE—By R. Bickerstaffe Holt, M. I. Mech. E., Highways and Permanent Way Engineer, City of Leeds. London: Tramway and Railway World Offices. Cloth; 6x10 in.; pp. xv + 249; 150 illustrations. 10/6.

UNITED STATES BUREAU OF MINES—Washington, D. C. (Government Printing Office): Superintendent of Documents. 6x9 in.

Rules and Regulations for Metal Mines—By W. R. Ingalls, James Douglas, J. R. Finlay, J. Parke Channing and John Hays Hammond. Bulletin 75. Pp. 296. Paper, 35c.

United States Mining Statutes Annotated—By J. W. Thompson. Part I: Sections and Statutes Relating to Metalliferous and Coal Mining. Pp. 860. Part II: Miscellaneous Mining Subjects. Pp. 1772. Bulletin 94. Not sold separately. Cloth, $2.50.

WATER-SUPPLY PAPERS, UNITED STATES GEOLOGICAL SURVEY—Washington, D. C. (Government Printing Office): Superintendent of Documents. Paper; 6x9 in.; illustrated.

No. 332-B: Surface Water-Supply of the United States, 1912. Part XII: North Pacific Drainage Basins; B. Snake River Basin—By Nathan C. Grover, Chief Hydraulic Engineer and G. C. Baldwin and F. F. Henshaw, District Engineers. Pp. 277.

No. 362-C: Surface Water-Supply of the United States, 1913. Part XII: North Pacific Drainage Basins; C. Lower Columbia River and Roque, Umpqua, Wilson and Nehalem Rivers—By Nathan C. Grover and F. F. Henshaw. Pp. 246.

No. 371: Equipment for Current-Meter Gaging Stations—By G. J. Lyon. Pp. 64.

No. 375-F: Conditions Requiring the Use of Automatic Gages in Obtaining Records of Steam Flow—By C. H. Pierce. Pp. 131-139.

YEAR-BOOK OF THE NEW YORK SOCIETY OF ARCHITECTS—New York City (366 Fifth Ave.): William T. Towner, Secretary. Flexible leather; 6x9 in.; pp. 241. $5.

Besides matter pertaining to the society itself and some New York directory features and building statistics, the bulk of this volume consists of the building code of New York City, the tenement-house law applicable to first-class cities in New York State and the state labor law, applicable to factories and mercantile establishments.

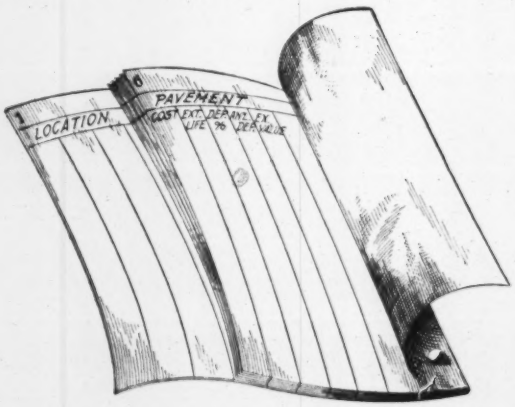
Field and Office

Handy Book-form Data Sheet for Valuation Work

By Robert E. Klotz*

In compiling data for valuations of physical property the custom of assembling all details on one sheet has resulted in the use of sheets of such large size that in some cases two men are engaged in assembling the statistics on one sheet at one time. These sheets are awkward for both compilers and users, owing to the space required in handling and the difficulty of tracing items far removed from their identifications.

In compiling a track and roadway valuation for an electric railway in New York City during the latter part of 1914 and the early part of 1915 I found that a single sheet sufficiently large to accommodate the necessary



DATA SHEET ARRANGED IN BOOK FORM

details would prove inconveniently large both in assembling the data and in referring to them in connection with the litigation for which the valuation was required. After some consideration of various schemes, I finally determined on a sheet made into book form, as shown in a general way in the accompanying sketch. This proved to be a very satisfactory form for the compiler, and it received the distinct approval of the counsel.

As may be seen from the illustration, the book consists of a first, or bottom, sheet sufficiently wider than the remaining sheets to provide, to their left, a space for the section designations, which will remain exposed when all the sheets are closed. The portion of this sheet covered by the others is identical with them in form, and is used for data in the regular manner. Thus in a typical book the first sheet of a railway-track valuation will contain the section designations on the left-hand portion and the data for tram rails on the right. The second sheet will have the data for ties; the third, that for pavement, and so on. The uppermost sheet gives a recapitulation.

While it may at first glance appear that this book would have a more uniform appearance were all the sheets identical and the designations repeated on each, the advantage of being able to retain a certain designation on a single sheet and at the same time refer, within easy reach, to any required data, more than offsets the esthetic shortcomings. Those who have used this book, while they have invariably commented at first upon its apparent "left-handedness," have found it so extremely convenient that I can recommend its adoption by others who may be occupied with the presentation of data or statistics.

*111 West 49th St., New York City.

Measuring-Boxes for Sand and Stone for Concrete Roads

Measuring sand and stone for concrete at the time it is loaded into wheelbarrows at the storage pile by the use of 2-cu.ft. measuring-boxes is called for in the specifications of the Coleman du Pont Road now being built in Delaware. The specifications are as follows:

> Great stress will be laid on the method of measuring the materials used in the concrete. It will not be allowed to measure the materials in ordinary wheelbarrows unless each load is struck perfectly smooth with a straight-edge. This is to insure perfect proportions in the concrete. Contractors shall use measuring-boxes or other similar device if so ordered by the engineer.

The engineer so ordered.

Bottomless boxes or frames are placed in a flat-bottomed wheelbarrow and filled with sand or stone. The

LOADING WHEELBARROW WITH CRUSHED STONE AND MEASURING LOAD AT SAME TIME

frame is then lifted up and the wheelbarrow wheeled to the mixer. In the accompanying view the boxes are being used to measure stone.

At first the contractors did not favor the boxes, but now, according to Charles Upham, chief engineer of the Coleman du Pont Road, Inc., they swear by them. A boxful does not overload the wheelbarrow.

An Electric Dragline Excavates 60,000 Yd. in 18 Days

Fast work was done by the operators of a 1¼-yd. electric dragline excavator on the drainage work of the Boise project, under way by the Reclamation Service. The *Reclamation Record* for October publishes the following data furnished by J. L. Burkholder, assistant engineer:

The machine was operated from noon on Aug. 14 continuously to the end of the month, and approximately three-quarters of the length excavated was in hard material which had to be blasted, 600 lb. of dynamite being used during the period. The dirt was moved at an average rate of two buckets per minute, or 2.3 cu.yd. per min. Counting the time actually spent in digging, the rate was 3 yd. per min.

RECORD ON 1¼-YD. ELECTRIC DRAGLINE

Operator	Amount Excavated Lin.Ft.	Cu.Yd.	Average Number of Cubic Yards Excavated Per Hr.	Per Shift
Martin	3,150	22,617.5	185.8	1,256.5
Gibson	2,680	19,787.7	175.9	1,164.0
Wirth	2,080	16,184.3	173.6	1,135.7
Total and average...	7,910	58,589.5	178.9	1,189.6

MACHINE EFFICIENCY

	Hr.	Per Cent.
Digging	327:30	77.2
Mechanical repairs	58:30	13.8
Electrical repairs	24:30	5.8
Moving	12:45	3.0
Blasting	0:45	0.2
Total	424:00	100.0

There were 49¼ shifts. The record run per shift was 1,583 cu.yd.

Inexpensive Bridge Railing

By George H. Ruhling*

A pipe railing with concrete posts was employed on two 100-ft. single-span concrete-arch bridges which were built across Honey Creek in Seneca County, Ohio, during the past summer. As the bridges were to be located some miles distant from any city, it was deemed inadvisable to build an expensive all-concrete railing. On the other hand, it was not desired to give the bridges a cheap appearance by using the ordinary pipe railing.

Before setting the post forms the two lines of 2-in. wrought-iron pipe were screwed together, lengths being selected so that the sleeves would not come within any posts. The pipe was then painted with two coats of red lead and raw linseed oil, the second coat containing sufficient graphite to give a brown tint. When the paint was dry the pipe was incased in the forms for the posts. These were built in halves and when the pipe was raised to the proper height the halves would slip together, in which position they were secured by two wooden straps running entirely around the form. Where the pipe passed through the form it was wrapped with two layers of asphalt paper. Concrete (1:2:3) was then poured. After the forms were removed the posts were rubbed down with carborundum blocks.

This railing is inexpensive, strong and presents a pleasing appearance. Connecting the pipes together before placing them in position produces a good alignment throughout. The asphalt-paper separators between pipe and concrete allow the pipe to contract or expand independently of the posts. At the same time the pipe is held firmly in position. The pipe works back and forth through the end posts in moderate summer weather.

The writer in conjunction with Charles J. Peters, County Surveyor, designed the bridges and railing. The contractor for the work was the Burke Construction Co., Newcastle, Ind.

*Deputy County Surveyor, Tiffin, Ohio.

GENERAL APPEARANCE OF CONTINUOUS-PIPE RAILING

Concrete Cost Computing Chart

A chart from which the cost of a cubic yard of concrete may be readily traced for different variations in mix and cost of material has been prepared by A. P. Hoover, engineer with the John W. Ferguson Co., building contractor, Paterson, N. J.

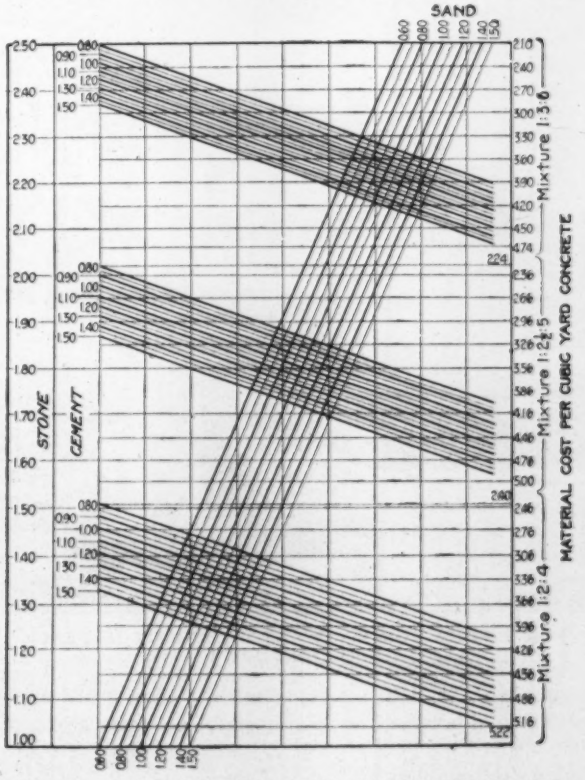


CHART FOR COMPUTING COST OF CUBIC YARDS OF CONCRETE
Devised by A. P. Hoover

On this chart (reproduced herewith) will be found a schedule of prices for stone, cement and sand, in addition to the figures given for the cubic yard under each of the three mixes. Assuming stone at $1.90 per cu.yd., sand at $1 per cu.yd. and cement at $1.40 per bbl., the procedure is as follows:

Follow the horizontal line representing $1.90 for stone until it intersects the diagonal line representing $1 for sand. From this point proceed vertically until reaching the diagonal line representing $1.40 for cement. If the mix is 1 : 2½ : 5, it will be found that the material cost of a cubic yard is $4.04. Similarly, for a 1 : 2 : 4 mix the cost would be $4.32. For 1 : 3 : 6 the cost would be $3.84.

Such a result may be obtained very quickly after a little experience, and in the original chart, which is 12x18 in., the accuracy may be depended on within about 1 per cent.

Concrete Bridge Manhole Form

On the bridge now under construction across the harbor at Portland, Maine, the conduit manholes are built as overhanging boxes tied into the curb-line or outer main girder below the bracketed sidewalk and additionally supported by a bracket, the reinforcement of which also ties into that of the girder. Fig. 2 shows one of these manholes after completion.

The forms for these manholes are put together in one piece on the ground and the reinforcement is all wired into place before the form is lifted into place on the bridge and there joined to the formwork for the bridge proper. After the concrete has set the forms are taken down in sections and are again set up as before for use on the next manhole.

The bridge is under the supervision of J. R. Worcester & Co., Engineers, Boston, Mass., and the superstructure is being built by the T. Stuart & Son Co., Newton, Mass.

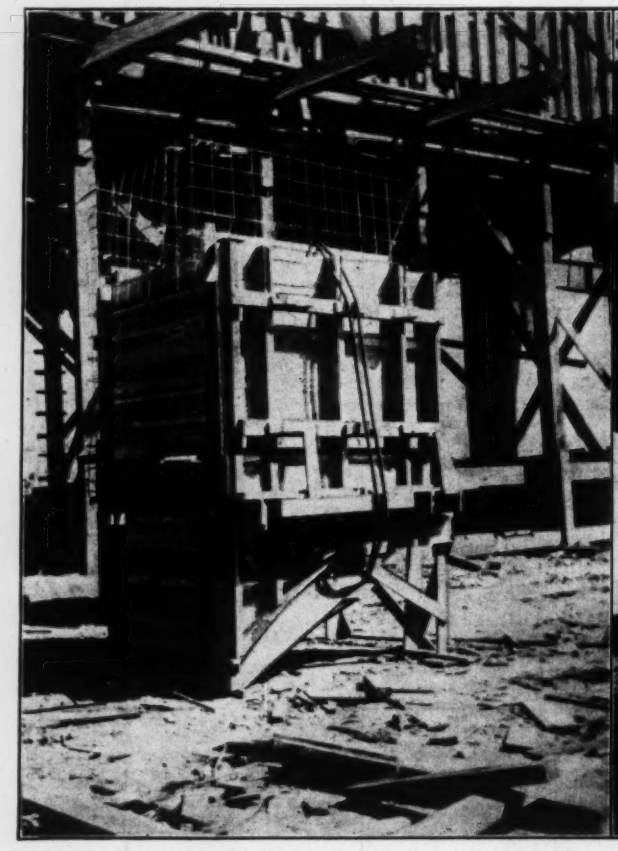


FIG. 1. FORM FOR SUSPENDED MANHOLE IN PLACE ON GROUND

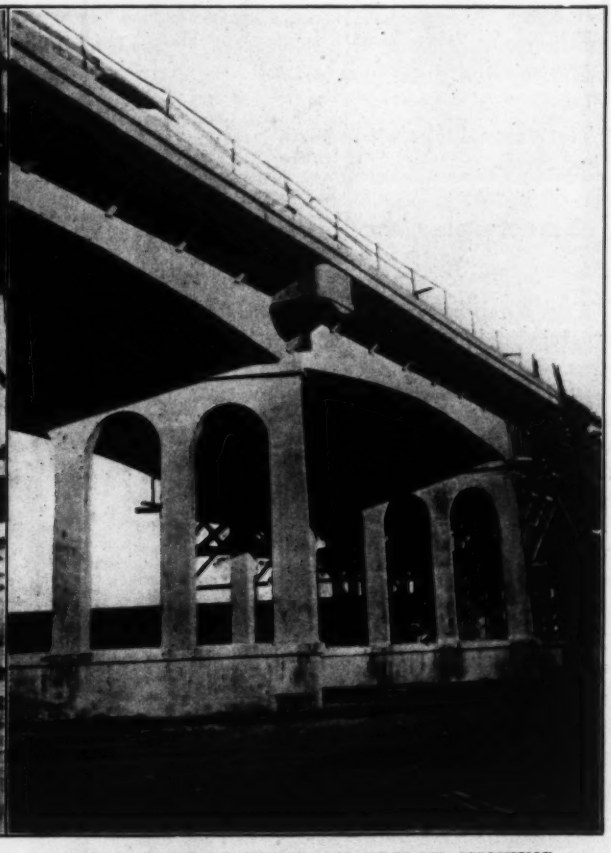


FIG. 2. PART OF PORTLAND BRIDGE, SHOWING SUSPENDED MANHOLE

Eccentric Heel Joint of Roof Truss: Solution of Problem

By Edward H. Rockwell*

The article of E. Godfrey, entitled "Moments at Eccentric Heel Joint of Roof Truss," in *Engineering News* of Aug. 26, 1915, deals with an important principle in structural design, as indeed is stated in the article itself, but a careful examination shows errors of large magnitude, the moments stated being only about one-half the actual ones in the chord members. In fact the method proposed does not seem to possess the finality and exactness one is led to expect from the comments on other solutions.

Fig. 1 herewith is the same as given in the prior article, except that the dotted member *EB* has been added. Mr. Godfrey computes the stress in *ED* by an equation that implies the presence of *EB*. He states that in the graphical construction an assumed member *BE* or *DF* could be used, but that such a construction would give incorrect stresses. This is quite true, and since he has implied the use of *EB* his results are also incorrect. If the use of *EB* is not assumed in computing *ED*, then the figure *EDBF* is assumed to be a solid beam with web, in

*Professor of Structural Engineering, Tufts College, Mass.

which case again the stress computed for ED is incorrect for every point in ED except at X, since taking moments about any point in FB except B gives a different result.

The expression in that article for shear in member ED, $\frac{R\ (b\ -\ a)}{b}$, is simply the value of such a vertical component in ED as will make the resulting stress exactly coincident with the neutral axis of ED provided EB is in the frame. The difference $R\ -\ \frac{R\ (b\ -\ a)}{b}\ =\ \frac{Ra}{b}$ is simply the amount of shear taken by the member EB. Mr. Godfrey supposes he has not used EB and therefore divides the shear $\frac{Ra}{b}$ between the chords according to a law discussed in what follows, computing M from these shears. Let us consider what happens to his solution if EB is absent. The stress in FB must now equal the horizontal component of ED, or $\frac{R\ (b\ -\ a)}{DB}$, in order that $\Sigma H = 0$. Fig. 2 represents a free body subjected to the forces as given in the article; D' and B' are the middle points of the chords in the portion l_2, and by the assumption of equal rigidity of joints E, D, F and B are points of contraflexure; $\frac{Ra}{b}$ equals the sum of the vertical forces at D' and B', which are assumed to cause moments in the chords. The equations $\Sigma V = 0$ and $\Sigma H = 0$ are both satisfied. But the equation $\Sigma M = 0$ is not satisfied: Taking moments about E,

$$\textit{clockwise moment} = \frac{Ra}{b}\left(\frac{l_2}{2} + c\right)$$

$$\textit{anti-clockwise moment} = \frac{R\ (b\ -\ a)}{DB} \times EF,$$

and since $\frac{EF}{DB} = \frac{a}{b}$

$$\textit{anti-clockwise moment} = \frac{Ra}{b}\ (b\ -\ a)$$

and the ratio between the clockwise and anti-clockwise moments equals

$$\frac{\frac{l_2}{2} + c}{b\ -\ a}$$

which when c is very small approaches the value ½, whereas it ought of course to equal unity. In other words, the heel joint is not in equilibrium, and if this solution is properly corrected the resulting moments in the chords will be nearly twice the amounts given.

Distribution of Moment Between Chords

Let Fig. 3 represent a joint of three members subjected to a moment caused by imperfect articulation of the members.

The change of slope α is the same for all three members, and if the adjoining truss joints are of equal rigidity, then the points of contraflexure are at the midpoints of the members. Also, for small values of α

$$\sin \alpha = \alpha = \frac{\Delta_1}{\frac{1}{2} l_1} = \frac{\Delta_2}{\frac{1}{2} l_2} = \frac{\Delta_3}{\frac{1}{2} l_3}$$

The true resultant stresses on the joint members all meet at some point to be determined, and these lines of stress must pass through the respective points of contraflexure, at which points there will be forces P_1, P_2, etc., normal to the members which when combined with the longitudinal stresses S_1, S_2, etc., make the true stresses F_1, F_2, F_3, etc.

Then

$$\Delta_1 = \frac{P_1 \left(\frac{l_1}{2}\right)^3}{3\ EI_1},\ \Delta_2 = \frac{P_2 \left(\frac{l_2}{2}\right)^3}{3\ EI_2},\ etc.$$

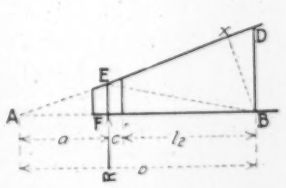


FIG. 1

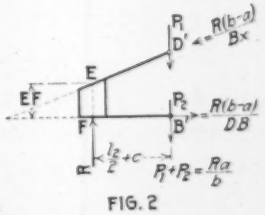


FIG. 2

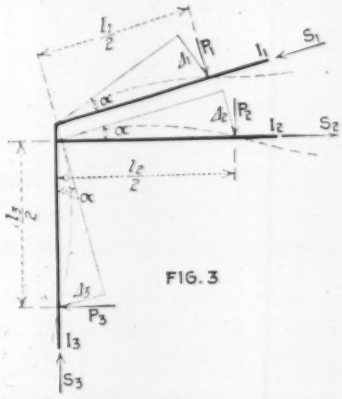


FIG. 3

FIGS. 1 TO 3. DIAGRAMS OF ECCENTRIC HEEL JOINT

Substituting the various values of Δ,

$$a = \frac{P_1 \left(\frac{l_1}{2}\right)^2}{3\ EI_1} = \frac{P_2 \left(\frac{l_2}{2}\right)^2}{3\ EI_2} = \frac{P_3 \left(\frac{l_2}{2}\right)^2}{3\ EI_3}$$

But the moments in the members are $M_1 = ½\ P_1\ l_1$, $M_2 = ½\ P_2\ l_2$, etc. Substituting again,

$$a = \frac{M_1 \frac{l_1}{2}}{3\ EI_1} = \frac{M_2 \frac{l_2}{2}}{3\ EI_2} = \frac{M_3 \frac{l_3}{2}}{3\ EI_3}$$

Thus $M_1 = 6\ Ea\left(\frac{I_1}{l_1}\right)$; $M_2 = 6\ Ea\left(\frac{I_2}{l_2}\right)$; $M_3 = 6\ Ea\left(\frac{I_3}{l_3}\right)$

The coefficient $6\ E\ a$ is constant for all values of M in the members at any joint, hence

$$M_1 : M_2 : M_3 = \frac{I_1}{l_1} : \frac{I_2}{l_2} : \frac{I_3}{l_3}$$

In this case therefore moments are to each other as the quantities $\frac{I}{l}$, and not (as stated by Mr. Godfrey) as the quantities $\frac{I}{l^3}$. He obtains the latter expression by assuming moments to vary inversely as deflections, which is untrue.

Solution of Problem, Partly Graphical

The best solution of this and similar problems is based upon the principle that, however eccentric the members of a joint may be, the actual resultant stresses themselves at any joint always meet in a point; otherwise the joint is not in equilibrium. When these true lines of stress are located the direct longitudinal stresses and the moments

are as easily determined as for an arch-ring from its line of pressure.

By the assumptions of this problem the support takes no moment, and therefore the point where the true lines of stress intersect is on a vertical line EF through the

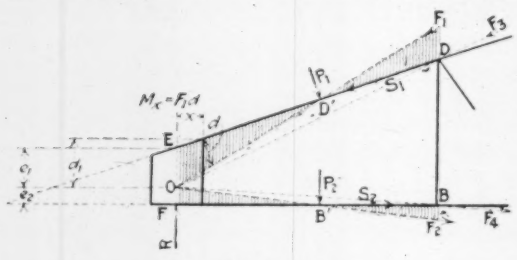


FIG. 4a

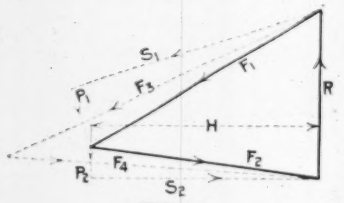


FIG. 4b

FIG. 4. SOLUTION OF PROBLEM OF ECCENTRIC HEEL JOINT

reaction. The moment, whose amount is as yet unknown, divides between the chords, whose horizontal components of stress are equal. Since M_1 = hor. comp. of $F_1 \times e_1$, and M_2 = hor. comp. of $F_2 \times e_2$,

$$\frac{M_1}{M_2} = \frac{e_1}{e_2} = \frac{\frac{I_1}{l_1}}{\frac{I_2}{l_2}} = \frac{I_1 l_2}{I_2 l_1}$$

in which e_1 and e_2 are measured vertically along EF from the chord axes and $e_1 + e_2 = EF$. In Fig. 4a, EF is therefore divided in the given ratio and the point O is the point at which the actual stresses meet.

For the assumption of equal rigidity in all the different truss joints, lines OD' and OB' are the true lines of stress, whose values are shown as F_1 and F_2 in Fig. 4b. The direct longitudinal stresses are S_1 and S_2. The shears at points of contraflexure are P_1 and P_2. The moment diagram for member ED is $ED'O$, in which the moment at any point x from E equals $F_1 d$ or $H d_1$. If lines of stress are assumed to pass through D and B (when these joints have no rigidity), then F_3 and F_4 in Fig. 4b, now drawn parallel to OD and OB, are the true stresses.

Draftsman's Erasing Knife—A rather clever and efficient little scratcher for the draftsman's use can be made from an old safety-razor blade and a 5- or 6-in. piece of ⅛-in. copper wire. The wire should be split longitudinally for about ¼ in. by a jeweler's hacksaw, and a portion of the blade soldered into position in this slit, using a small blowpipe with a candle as source of heat, or a blue gas flame. Any soft solder and its appropriate flux, as muriatic acid and tin, will work, but the most convenient flux and solder is "Solderall," which is a pure tin, finely ground, mixed with flux and put up in tubes ready for use. After soldering, the steel may be ground to any desired shape, giving a very thin, sharp edge, which will remove an inked line without cutting the paper or tracing cloth. Incidentally it may be mentioned that "Solderall" is part of every chainman's equipment in the Surveying District of Arizona, it being supplied by the Surveyor-General, together with a number of sleeves just fitting the tape used. If a break occurs in the field, the men fit the broken ends into a sleeve, put "Solderall" at both ends of the sleeve, and hold a match under it.—H. N. Bradstreet, Phoenix, Ariz.

Gasoline Shovels Are Auxiliary to Steam Equipment

There are many localities where the enforcement of smoke ordinances, the cost of coal and water or the demand for licenses for firemen and engineers prevents the use of steam shovels and makes advisable the employment of one driven by gasoline power if certain handicaps of the latter can be overcome. The gasoline shovel therefore has been designed to satisfy a certain limited demand, rather than to produce a machine in competition with the steam shovel. By the use of gasoline shovels a great reduction is possible in some work which contractors have previously done by hand. Gasoline shovels will probably be restricted to medium and light excavation.

Several designs of gasoline-power shovels have been brought out recently, prominent among which is that of the Marion Steam Shovel Co., of Marion, Ohio. The following notes on the equipment and operation of this type have been obtained from the company.

The Marion design has been developed only in the revolving type. All operations are performed by power from one engine and the operation is controlled by friction clutches of the outside-band type. The engine is a constant-speed, four-cylinder, four-cycle vertical marine type with a throttling governor, jump-spark ignition and high-tension magneto. It is splash-lubricated and has a cooling-water pump. A flywheel is carried between the engine and the load to relieve the crankshaft of stresses due to sudden changes in torque. Any fuel can be used down to that of 39° Bé., provided the proper carburetor is employed.

On the end of the engine shaft is a bevel pinion which meshes with two bevel gears loose on a reversing shaft (A in accompanying view). One or the other of these is connected to the shaft by friction clutches. Placing the lever for operating these clutches on center will release both clutches. Geared to the reversing shaft is the hoisting drum C. This is of differential or stepped type, instead of the usual straight barrel seen on steam shovels. This scheme is employed to give greater pull and slower speed on starting the dipper out of the pit and an increased speed with lighter pull when the dipper clears the bank. In this way the difficulty of using a constant-speed drive is minimized. Forward of the hoisting-drum shaft and connected to it by an intermediate shaft E, with gears, is a pair of reversing gears with friction clutches—an arrangement similar to that on the main

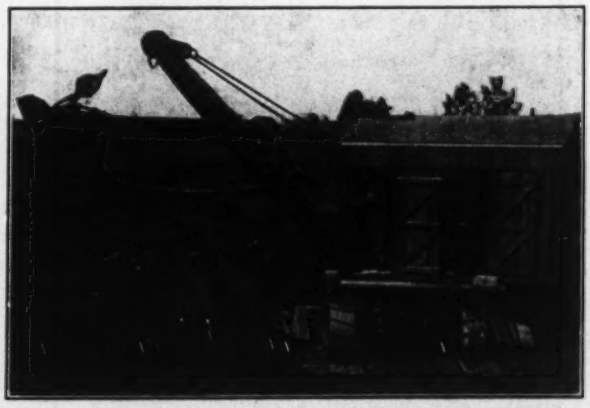


FIG. 1. REVOLVING SHOVEL WITH GASOLINE-ENGINE DRIVE

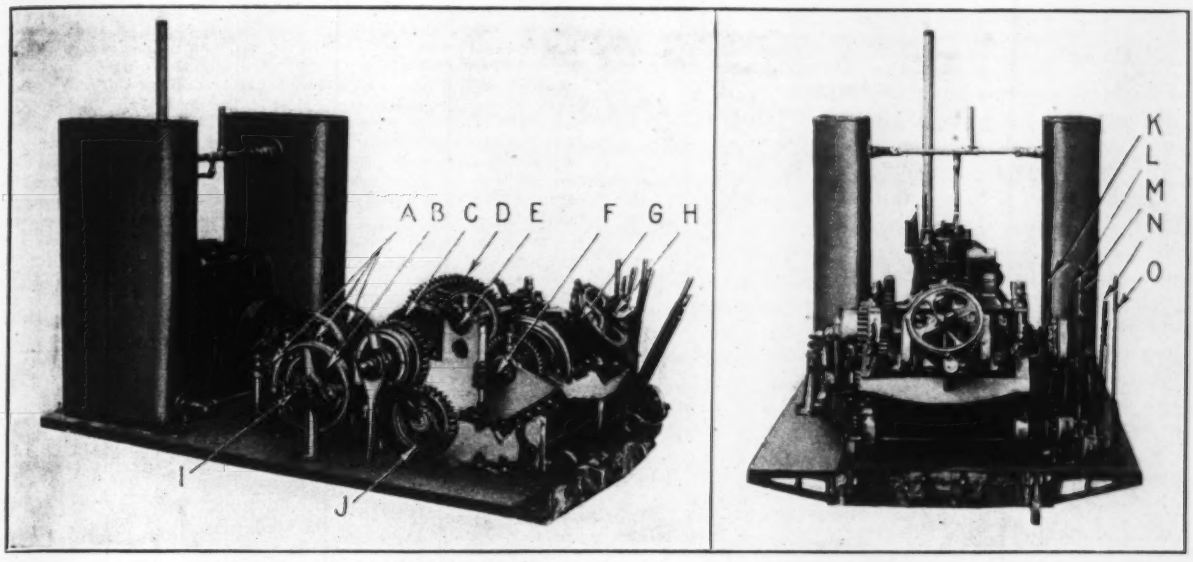


FIG. 2. TWO VIEWS OF POWER AND GEARING UNIT OF A MARION GASOLINE SHOVEL

reversing shaft just mentioned. These control the crowding of the dipper handle, and are both governed by a single lever arranged so that when in central position both frictions are released and a brake *G* is set to hold the dipper handle in any position. Meshing with the reversing bevel gears on the intermediate crowding shaft is a bevel gear on a shaft *H*, running at right angles and having telescopic joints connecting to the crowding gear on the boom. This allows for variation in height of the boom.

The propelling of the shovel is done from a friction clutch and gear *J* mounted on the end of the hoisting-drum shaft. The gear meshes with another gear keyed to a horizontal shaft running directly over the rotating center. Here the shaft carries a bevel pinion, which engages with a bevel gear on the vertical propelling shaft, the lower end of which drives the shovel exactly as on the steam type. Reversing the drive is done at the main reversing gears already noted.

The shovel is swung by a spur gear carried on the main reversing shaft. This gear engages a corresponding spur gear fixed on a swinging shaft *I*, each end of which has a drive-wheel keyed to it and a corresponding friction housing *B*, which is keyed to a gear mounted loosely on the same shaft (with bronze bushings). Both of these gears on the swinging shaft are controlled by outside band frictions, duplicates of those on the reversing shaft; each gear engages another gear keyed to a short shaft below and forward. At the outer end of each short shaft is a bevel pinion meshing into a swinging crown gear on a vertical swinging shaft. The other end of each of these last shafts, exactly as on a steam shovel, carries a spur pinion meshing with a large rotating gear on the lower frame of the shovel. Since there are two swinging mechanisms between the bull wheel and the intermediate swinging shaft, the shovel can be turned in one direction or the other, according as one gear or the other on the intermediate shaft is engaged.

The operator's control of the gasoline shovel is kept identical with that of a corresponding steam shovel; the operating levers have the same position and work in the same manner. The gasoline shovel is a one-man machine—the elimination of the boiler makes a fireman unnecessary. It is not necessary for the operator to leave the shovel levers to look after the engine.

The gasoline type of shovel can be converted into a single-motor electric shovel by the substitution of an electric motor of the proper capacity in place of the gasoline engine. With the control gearing described a constant-speed alternating-current motor may be employed.

Azimuth by a Simple Method

By J. A. Macdonald*

The usual method of obtaining azimuth from Polaris is by making observations at elongation. The following method, not new but little known, will be found much simpler in application and fairly accurate. No instrument and no nautical almanac or mathematical tables are needed.

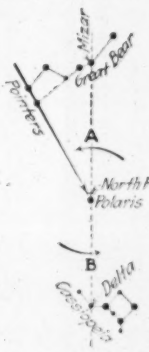
This method is based on the fact that Polaris and two adjacent bright stars are in the same vertical plane only a few minutes before Polaris crosses the meridian. It can be used at only one moment in each 24 hr., and a fairly clear sky is required to enable the stars to be sighted behind a plumb-line. The two stars that can be used in this observation are Mizar, the middle star in the tail, or handle, of the Great Bear, or Dipper; and Delta, in the constellation Cassiopeia. The former can be used only when it is below the pole during the night; when it passes the meridian above the pole it is too near the zenith to be of service, in which case the latter star is observed. The accompanying diagram shows the principal stars of the

OBS. ON MIZAR		OBS. ON DELTA CASSIOPEIA	
Jan. 20	5:22 a.m.	July 20	5:30 a.m.
Feb. 20	3:20 a.m.	Aug. 20	3:28 a.m.
Mar. 20	1:30 a.m.	Sept. 20	1:26 a.m.
Apr. 20	11:24 p.m.	Oct. 20	11:24 p.m.
May 20	9:26 p.m.	Nov. 20	9:22 p.m.
June 20	7:24 p.m.	Dec. 20	7:24 p.m.

*Topographical Surveys Branch, Ottawa, Ont., Canada.

constellation of Cassiopeia and the Great Bear, with Delta Cassiopeia, Mizar and Polaris on the meridian. The table shows the exact time at which these stars are in the same vertical plane on given dates. The time for other days can be secured by direct interpolation, the daily variation being 4 min. of time.

When it has been determined by observation that Polaris is in the same vertical plane with one of these stars, it can be shown that it will pass the meridian 7.8 min. later during 1915. This interval is increasing from year to year at the rate of 0.33 min., so that in 1916 the interval will be about 8.14 min. The observation can be made either indoors or out by suspending an ordinary plumb-line and marking the direction of the meridian by setting a second point at the stated interval after the two stars are in the same vertical plane.



MERIDIAN PASSAGE OF POLARIS

Table of Chains to Feet

In districts where old deeds generally give distances in chains and links the surveyor will find it advantageous to keep the accompanying little conversion table in his notebook. It gives the feet for each whole number of

CHAINS AND LINKS REDUCED TO FEET

	0	1	2	3	4	5	6	7	8	9	
0	0	66	132	198	264	330	396	462	528	594	0
10	660	726	792	858	924	990	1,056	1,122	1,188	1,254	10
20	1,320	1,386	1,452	1,518	1,584	1,650	1,716	1,782	1,848	1,914	20
30	1,980	2,046	2,112	2,178	2,244	2,310	2,376	2,442	2,508	2,574	30
40	2,640	2,706	2,772	2,838	2,904	2,970	3,036	3,102	3,168	3,234	40
50	3,300	3,366	3,432	3,498	3,564	3,630	3,696	3,762	3,828	3,894	50
60	3,960	4,026	4,092	4,158	4,224	4,290	4,356	4,422	4,488	4,554	60
70	4,620	4,686	4,752	4,818	4,884	4,950	5,016	5,082	5,148	5,214	70
80	5,280	5,346	5,412	5,478	5,544	5,610	5,676	5,742	5,808	5,874	80
90	5,940	6,006	6,072	6,138	6,204	6,270	6,336	6,402	6,468	6,534	90
	0	1	2	3	4	5	6	7	8	9	

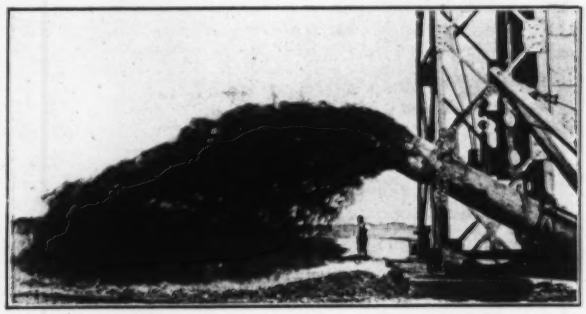
chains up to 99; and as links are hundredths, they can also be read off (by pointing off two places) and added to the chains. The table was computed by George M. Foulds and J. E. Thorup, Hackensack, N. J., who have found it very useful in their own work. Suppose a deed calls for a length of 16 ch. 27 lks. From the table 16 ch. is read as 1,056 ft., and 27 lks. (read 27 ch. and point off two places) as 17.82 ft. The sum, 1,073.83 ft., is obtained by mental addition.

NOTES

Lighting Blasting Fuse—The United States Bureau of Mines has recommended a new scheme to replace splitting the end of the fuse and touching off with a lighted match. The scheme has been devised by W. C. Cope, of the bureau, and is of service only where single pieces of fuse are used. A safety match is held against the powder core at the end of the fuse and the matchbox drawn across the match, causing the match and powder core to inflame immediately. It will be noted that this is just the reverse of the usual way of lighting a match—drawing the match across the box. In case safety matches are not at hand, the ordinary household match can be used by placing one match against the powder core and then lighting another and quickly touching it to the first one.

Two Mixers on One Tower—In the construction of the Speed Building at Louisville, Ky., two mixers are being used. At the beginning of the job they were used independently to pour at separate points. It was found that it would be more economical to arrange them so that they could use one tower. One mixer, a Smith gasoline ¾-yd., is at the base of the tower in the pit, while a Milwaukee steam mixer of the same capacity is opposite the tower on the outside and discharges into a chute to a hopper at the bottom of the tower, into which the Smith mixer discharges directly. The operating force consists of a combined engineer and feed operator on the gasoline mixer, an engineer for the steam mixer and a hoisting engineer. The bucket makes a trip every 30 sec. instead of every 1½ min., as at first. The Alfred Struck Co., of Louisville, is the general contractor.—R. B. Shapinsky, Louisville.

High Yardage Record for Hydraulic Dredge—The accompanying view shows material discharged by the 20-in. hydraulic dredge "Stanwix," owned and operated by Grant Smith & Co. & Locher, Rome, N. Y. (built by the Morris Machine Works). This machine was in operation on the New



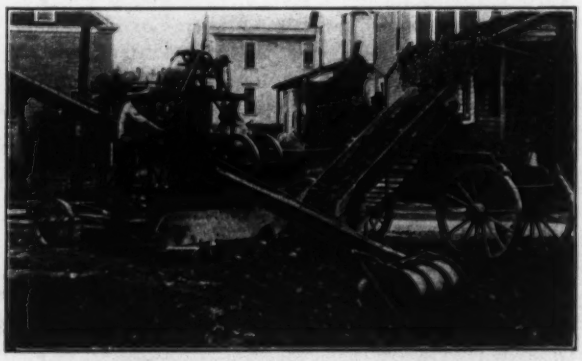
DISCHARGE FROM DREDGE "STANWIX," AT ROME, N. Y.

York Barge Canal at Rome, pumping 800 cu.yd. per hr. (the solid material was a heavy gravel) through 300 ft. of pontoon line and against 12-ft. elevation. It was necessary to deposit a considerable amount of spoil in a small area, which accounts for tilting up the discharge pipe at the angle shown.

Piledriving Formula Wanted for Steam Hammer—Is there in common use any formula that applies to Union Iron Works driver No. 3? I have endeavored to work out a formula from the one ordinarily used, but would like to know what has been customary among engineers.—R. S., Hammond, Ind.

Soil Analysis and Track Construction.—The mechanical analysis of soils, according to Bulletin No. 384 of the United States Bureau of Soils, Department of Agriculture, is recommended by the Way Committee of the American Electric Railway Engineering Association in studying good and poor results with various types of track construction. This analysis classifies material as fine gravel, coarse sand, medium sand, fine sand, very fine sand, silt and clay, according to size of grains.

A Dipper-Handle Drag Scraper—The excavating machine shown herewith has a scraper bucket attached to a rigid boom or handle, which is racked in and out like the dipper handle of a steam shovel. The reach and inclination of the handle are under control of the operator. The scraper delivers



A DRAG SCRAPER WITH RIGID DIPPER HANDLE

its load to the boot of an inclined elevator, consisting of a belt of transverse slats attached to side chains. Power for the excavator and conveyor is supplied by a gasoline engine mounted on the frame of the machine. This excavator was built by a Pittsburgh, Penn., man as a trial device, but it is of sufficient interest to warrant this description.

Editorials

Railway-Track Maintenance

Probably no more alarming picture of defectively maintained railway track has ever been printed than is found in a recent report of the Interstate Commerce Commission's inspector. His remarks are incidental to the description of a train accident, to which the defective spiking and bolting of the rails was a contributory cause. To quote directly:

> At many points spikes were found which were standing away from the rail or which failed to overlap the base of the rail, while many of the splice bolts were loose and some were missing. Measurements were taken in three places of the gage of the second rail east of the point of accident, where it had not been disturbed by the temporary repairs, and the gage was found to be 4 ft. 9¾ in. at one point and 4 ft. 9¼ in. at the other two points. Variations in gage of this character were prevalent. The ties were badly base-worn in many cases and there were also many low joints. The inside rail at the point of derailment had been elevated about 1 in. by the use of shims and braced by planks 11 in. long and 1 in. and 2 in. in thickness. West of the point of derailment one rail was found which had no spikes at the joints, while some of the bolts in the joints were loose. The first spike on the western end of this rail was 53 in. from the end of the rail, and this spike was not holding. The first spike which was holding was 57 in. from the end of the rail. The next spike was 77 in. from the end of the rail and was not holding. On the inside of this rail there were 15 spikes, 8 of which were standing away from the rail and were not holding. On the outside there were 15 spikes, 3 of which were not holding. On another rail west of the point of derailment there were only 3 spikes on the inside of the rail which were holding in a distance of 20 ft. 8 in. The gage of this rail as measured at three different points was 4 ft. 9⅜ in., 4 ft. 9½ in. and 4 ft. 9⅞ in.

Engineering News strongly hopes and believes that such conditions are not very common on American railways. There is no reason to assume, however, that on the particular railway with which the report deals such conditions are only local. So far as the Interstate Commerce Commission report indicates they are typical conditions on that railway. Let all railway passengers hope that they will not long remain normal even on that road.

Of course—the reader will say—the public is amply protected in such matters as this by its national supervisory and inspection authority, the Interstate Commerce Commission. That commission, he will say, will, after noting defects of this kind, promptly proceed to make a thorough investigation of all neighboring track, perhaps of that entire railway, and possibly also of other railways, to determine whether similar dangerous track is found elsewhere and to see that it is immediately brought up to a safe standard. Thus the traveler is protected from abnormal risk of accident—one might almost say, the certainty of accident.

Unfortunately, the case is entirely different. The Interstate Commerce Commission does *not* investigate track conditions elsewhere than just at the point of an accident of this kind. Officials of the commission assert that they absolutely lack legislative authority to investigate. They claim that they are not permitted to determine the safety or dangerousness of railway track, structures or equipment *except after an accident*. Even then they are restricted to the immediate vicinity or direct physical factors of the accident. Our railways may be using dozens or hundreds of weak and unsafe bridges; they may be running over track that has deteriorated so badly as to put every train running over it in momentary danger of being wrecked. Any such conditions, the Interstate Commerce Commission officials declare, must continue to exist, and the commission is powerless to call for remedies or *even to investigate*.

If the commission is right in this view, its powers need extending by legislation at the next session of Congress.

District Representatives of Utility Commissions

A herculean task has been placed on the state commissions for the regulation of public utilities from Maine to California. The great amount of work with which these commissions are loaded leads either to hurried investigations and judgments or to long delays. Complaint comes from certain parts of the country that the state commissions are not in touch with local conditions in the remote parts of the state; and out of this and other complaints nas grown the movement for transferring the control of city utilities to local public-service commissions.

This would be full of danger. Such local commissions, experience demonstrates, find it difficult to deal fairly with franchise corporations against the pressure of local public opinion and political attack. If public regulation becomes unfair to capital, no more money can be secured for extensions, proper maintenance will become difficult and public ownership and operation will be the only alternative.

A suggestion that opens a way by which state utility commissions may better satisfy the public demands that the commission shall be in touch with local necessities has been suggested in a letter to *Engineering News* by Prof. Olin H. Landreth, of the Engineering School of Union College, Schenectady, N. Y.—who, by the way, was the only engineer among the 300-odd members of the recent New York State Constitutional Convention. Although Professor Landreth had in mind only New York State, it will be seen that his plan, as presented below without the change of a single word, would be equally applicable to many other states of the Union:

> The plan hereby suggested to improve this defect is that the commission should establish in each of the larger cities of the state a local office in charge of an able, impartial and tactful representative, who would be more than inspector and less than judge, but whose duty would be to keep himself thoroughly informed as to the workings of each of the corporations operating within his territorial jurisdiction and whose duty would also be to hear and investigate tentatively all local complaints and suggestions regarding the quality of the service rendered. While the public and the corporations regulated should still retain the right of final judicial determination by the commission itself, it would doubtless prove to be the case that a large proportion of the matters which now are brought to the commission itself, and many more which are not brought, owing to the remoteness of the commission's headquarters, would be heard and amicably adjusted by the local representative himself, resulting in decidedly better service to the public, a more friendly feeling

between the public and the corporations and an enormous lightening of the burden now thrown on the commission itself. An able, impartial and tactful man, having secured the confidence and respect of both parties between whom it would be his duty to mediate, would be able to accomplish far more by close-range contact and familiarity with local conditions than the formal commission operating at long range and through its system of necessarily formal procedure. The Public Service Commission, when relieved of the burden of trivial complaints and of the tedious procedure necessary to hear and adjust them, would be able to devote its attention more thoroughly to the important judicial matters which come before it.

Although the plan is new as applied to public-service commissions, the underlying principle is not novel. Both in the government service and in great private corporations it has been deemed wise during the last dozen years to multiply district offices and to give those in charge of them greater authority.

It may be claimed that a public-service commission is a judicial body and cannot delegate any part of its authority to deputies, as an executive official can. In answer to that, however, may be cited the extent to which judges delegate the hearing of cases to referees and masters. Surely a state public-service commission, which has been called a quasi-judicial body, could go as far.

Of course it goes without saying that such resident deputies of a public-service commission as Professor Landreth suggests should be men of the requisite ability; and such men would be worth, and should receive, a liberal compensation. This, however, is no objection to the scheme. People should understand that regulation of public utilities costs money and the cost must in the long run be paid by the public. Furthermore, if it is attempted to get something for nothing, to regulate public utilities in a cheap manner by the use of cheap men, the public itself it likely in the end to be the chief sufferer.

Slides or Leaks at Panama?

Anticipating by some weeks the recent heavy slides in the Panama Canal, a correspondent in a recent issue of *Reedy's Mirror* writes:

When the ditch was being forced through Culebra, which is a mountain of rotten earth, the sides frequently slid into the excavation, and just before the water was turned into the ditch all of the walls seemed to be firmer. After the water was turned in, we had reports that slides again occurred.

The real truth is that the canal leaks. As near as I can gather, it is necessary to have a minimum of 27 ft. of water at Culebra. The water seeps through until there is somewhere in the vicinity of a 20-ft. depth; as the water seeps through and runs back through the rotten mud, it undermines the sides, with the result that they break away and slide into the ditch. (It would be interesting to know whether there is actually any truth that slides occur.) It is safer for the builders of the canal to have it appear that shipping through the canal is held up by slides, rather than that the canal leaks. The public has been fed on Culebra slides so long that another report does not make it doubt the truth of it.

To prove that he knows whereof he speaks the correspondent declares that he took a trip through the Canal Zone in August, 1912, and was told a thing worth looking into, but easily proved or disproved. He writes:

While in Panama I met a number of the engineers. One of them told me, in the presence of a number of Americans, that one of the sides of a lock disappeared after it had been practically completed. If this is so, there is undoubtedly some subterranean lake, or perhaps the canal base is over a crater. Whether this is so or not can be determined by getting reports from the canal builders as to the cubic contents of all concrete walls that were constructed and then measuring up the present walls.

It does not seem to have occurred to this truth presenter and seeker that the method he proposes for determining whether the lock disappeared might be applied, with variations, to find out whether there really have been any slides—namely, to measure the earth dredged from the former free channel at the Culebra Cut.

"About This Time Look Out for Concrete Failures"

If construction men were provided with almanacs patterned after the old-fashioned farmers' almanac, the period from the middle of October to the first of December would be embraced by an italic line reading about as the one that heads these paragraphs. In the absence of any such guide it behooves such a journal as this to emphasize the danger such a laconic warning would try to point out.

Many concrete workers will consider this warning unnecessary. They have come to the common enough conclusion that a knowledge of the slow-setting qualities of concrete under a low temperature is a fundamental of the concrete business. A long experience with the peculiarities of some concrete foremen, and more especially a study of the concrete failures of the past, will convince anyone of the contrary. The fact is that while most constructors realize that concrete will not set in freezing weather, many do not appreciate that from 45° F. down to freezing there is a definite slowing up in the setting, which is actually more dangerous than a complete failure to set. Anyone ought to be able to recognize a frozen concrete; it takes a much higher degree of skill to determine a working-strength set.

For the next six weeks, in most parts of this country, night temperatures will be hovering around freezing, although in the daytime artificial heating of the concrete will rarely be required. In consequence, much concrete from which normally the centers could be removed in two to three weeks will be so retarded in set as to be dangerously near failure, unless supported for a week or two weeks beyond the standard period. If the discouraging records of all the autumns of the last ten years are not to be repeated, every man responsible for the laying of reinforced concrete will study his thermometer for the next month or two and be quick to protect his forms when the temperature gets into the forties.

It is a long way from South Carolina to California, but not so far but that the septic-tank explosion at Florence might have been heard of and prevented a like explosion at Pasadena. The Florence explosion (described in *Engineering News* of Feb. 25, 1915, page 410) was caused by burning grass and weeds around the tank. A few weeks ago workmen at Pasadena burned grass around the septic tank there, which caused an explosion in the tank that broke up a considerable portion of its reinforced-concrete roof. These incidents, together with the explosions in the Boston screen chamber, Ocean Grove gate chamber, Batavia pumping station and also the Pittsburgh and Detroit sewer explosions—all within a year or so—illustrate again and again that explosive gases accumulate in sewage-disposal works and sewage-collecting systems and that great care should be taken to guard against them. The primary aim should be to prevent the accumulation of gases; but since even then they may accumulate, a little common sense should be used about lighting cigars in chambers and sewers and setting fire to grass about septic tanks.

Letters to the Editor

How To Collect Royalties on Engineering Patents

Sir—I would like to add something to the current subject of patentees and royalties. The design of girderless plate floors (so-called flat slabs) is something now within the power of every engineer. The methods used by patentees and sanctioned in building ordinances have been published, so there is no mystery about it. In fact, the design of such a floor or roof is generally less arduous work than the design of ordinary beam and slab types. Since the recent decisions of the United States courts, the Flat Slab Patents Co. has been licensing engineers to design flat slabs. As a result of this condition I have had the following experience:

A client employed me to design a reinforced-concrete building. There was considerable chaffering about the price, as competition is strong this year, even when the competition with firms furnishing free (so-called) plans is not taken into account. When the work was started flat-slab men got wind of it and went after the owner. He considered the matter and concluded to have the building designed with flat-slab floors and roof. I informed him that to the cost of designing must be added the royalty of 1c. per sq.ft. This meant an addition of $600 to the engineering expense on the structure. It was too much, and he ordered work stopped. Later, he informed me that he found he could get the flat-slab design free of charge by permitting contractors to furnish competitive designs. So I will be employed merely to check the design of the lowest bidder, unless the bidders succeed in convincing the owner that he does not need an engineer.

It seems the better plan for the Flat Slab Patents Co. and other patentees would be to permit every engineer to design according to the patented method and then make contractors pay the royalty. In the specifications the amount of royalty to be paid can be mentioned, and every contractor can add it to his bid. In this way more business should be done, for engineers that feel they can consistently indorse any special system can be depended on to push its claims. However, when the royalty charge stares up in the face of an owner he will be inclined to do without an engineer and go to contractors for plans and specifications, which will be furnished free (?) by the lowest bidder.

ERNEST MCCULLOUGH.

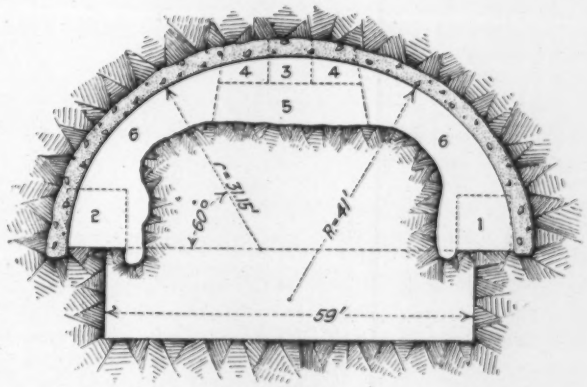
Monadnock Block, Chicago, Ill., Aug. 31, 1915.

Driving the Tunnel for the Marseilles-Rhone Canal

Sir—Having read E. L. Corthell's description of the "Rove Tunnel" on the Marseilles-Rhône Canal in *Engineering News* of Aug. 26, I wish to give a little more exact account of the procedure in excavating and lining that tunnel according to information given in the "Annales des Ponts et Chaussées."

Excavation was commenced by driving at the right a heading with a cross-section of 75 sq.ft., with its base at the elevation of the towpath. A second heading, of 96-sq.ft. section, was driven at the same elevation on the left side, parallel to the right heading; and for the purpose of checking the alignment and for ventilation, this was connected with the first heading by cross-drifts every 328 ft. A third small heading was then driven at the summit of the arch and openings of 43-sq.ft. cross-section were driven to this heading from the two side headings every 60 ft. This third heading was then widened and the excavated material was dropped through the cross-drifts into cars operating in the side headings. The top heading was then lowered and finally the connection with headings 1 and 2 was accomplished as shown in the accompanying sketch.

In the meantime the footings for the masonry arch were laid and the arch centering was erected, being supported on the unexcavated core of the tunnel. The masonry of the arch ring was laid in sections 19 ft. long. Every third one of these sections was built and then the intervening rings were undertaken. After the completion of the arch masonry, the remaining core was removed.



HEADINGS IN THE MARSEILLES-RHONE CANAL

Before the tunnel proper was begun, two shafts 11.48 ft. in diameter, distant 8,200 and 17,800 ft. respectively from the south portal, were constructed, the former having a depth of 460 ft., the latter of 230 ft. These will serve for the ventilation of the tunnel.

To the north of the tunnel is the "Gignac" cut. Near the portal its depth is 99 ft., with an upper width of 335 ft. The sides have a slope of 4 on 5, broken by berms 8 ft. wide, every 32 ft. vertically.

I think that it is slightly hasty to describe the "proposition of building this enormous and enormously costly tunnel merely to save the dwindling traffic by river barges a few miles of navigation in the open Mediterranean as a scheme that would appear absolutely quixotic from the economic point of view." You are no doubt aware that the French have long been masters of the science of eco-

nomics, and I venture to say that they have investigated the proposition in an economic way from all angles and that the canal will be a "paying proposition." It is to be regretted that canals in this country have not received the consideration and study due them, but I hope that time will convince our people when nothing else will.

RICHARD F. WAGNER.

Lynchburg, Va., Aug. 28, 1915.

[Referring to the last paragraph of the foregoing letter, it may be said that some of the ablest engineers of France have been outspoken in public criticism of some of the Government expenditures on waterways, urging that the traffic present or prospective was not sufficient to justify the outlay. In France, as in the United States, politics rather than engineering has often controlled the expenditures on waterways.—Editor.]

Advocating Limestone Concrete

Sir—Referring to the note requesting opinions on the quality of limestone concrete, in *Engineering News*, Oct. 7, 1915, p. 704: This company has for several years used crushed limestone for making machinery foundations, walls and various other things where the concrete has been under heavy load. Most persons who are familiar with cement-mill machinery will agree that everything around the cement plant has to be built very substantially and that the vibration set up in the grinding and pulverizing mills and crushers requires considerable strength in the foundations.

We have used crushed limestone in various grades from dust up to large pudding stones and in very few cases have made any use of sand, grading the limestone so as to get a very dense mass.

The highway commissioner of Wisconsin mentioned in the note seems to be straining at the gnat when he objects to the use of crushed limestone for the coarse aggregate in concrete-road construction.

We would not hesitate to recommend crushed limestone for any work where concrete is to be used.

SECURITY CEMENT AND LIME CO.,
Arthur C. Hewitt, Engineer.

Hagerstown, Md., Oct. 12, 1915.

Lighting Fuses with a Hot Iron

Sir—In *Engineering News* of Oct. 7, T. Ray Martin gives some advice on the lighting of a blasting fuse. I have done a considerable amount of blasting and have found that the safest way to light several fuses at a time is to use a short piece of iron rod ¾ to 1 in. in diameter and about 2 ft. long, heated to a white heat at one end. Touching the heated end of the rod to the square-cut end of the fuse will start the sputter so fast that the writer has lighted as many as 23 charges at one time, using a 24-in. length of fuse.

I don't think that it is a safe practice to light more than four fuses at one time with matches, for everybody knows how easily a match is blown out, and a man gets rather nervous when he is lighting fuses and can't get a light, while a fuse close to him may be burning its way to the charge beneath.

When lighting fuses with matches I have found it of assistance to cut the end of the fuse square and apply a very small amount of nitro-gelatin directly to the end of it. The thinnest film of nitro possible is best. This will help the lighting considerably.

GUSTAVE E. NYREEN.

290 Massachusetts Ave., Cambridge, Mass.
Oct. 12, 1915.

Sir—I note some discussion on the best way of lighting the ordinary safety blasting fuse. The method described by T. R. Martin on page 707 of *Engineering News* of Oct. 7 is undoubtedly superior to a torch or any other flame, large or small. It is probably the best method where only one fuse is to be lit.

Where there are several fuses, however, it is open to objections, and I can suggest a better method, namely, the use of a red-hot iron. I have found it best to employ a piece about ⅝ in. in diameter by about 10 or 12 in. long, heated for a distance of 2 or 3 in. at one end in an ordinary blacksmith forge.

The braid of the fuse should be split about ⅜ in., on the upper half only. By spreading the split it will form a small cup in which to hold the powder. It should be laid on a small, dry rock and another rock about as large as a man's fist placed on the fuse about 3 in. away. If the fuses are prepared in the manner cited they can be lit very rapidly. I have frequently seen one man in my employ light 8 or 10 before running for shelter, the fuses being 16 to 18 in. long. I think that is no more difficult than lighting four or five fuses with matches. One might suppose the iron would cool too quickly, but it does not, and anyone who tries this method is not likely to use any other as long as he has available a blacksmith fire and an old bolt.

J. M. BENJAMIN.

3738 Sheffield Ave., Chicago, Ill.

Largest Electric Drainage Pumping Plant

Sir—The article in the Sept. 23 issue of *Engineering News* entitled "Drainage Pumping Plant with Variable-Speed Drive" is of especial interest to engineers engaged in land-reclamation work in the Gulf-coast country on account of its description of the ingenious method of securing a variable pump speed from a nonvariable motor. The constant-speed conditions imposed by alternating-current motors make it difficult to apply them to drainage pumping on account of the various heads at which the pumps must be operated. Another feature of the plant that would be considered a novelty in Louisiana practice is the long discharge line running over the protection levee and approximately following the slope lines of it. Such construction has been considered prohibitive on account of the expense for long pipes and the friction losses in the pipe, but it is probable that at least in some of the projects where underlying strata of sand are encountered at depths of 3 to 10 ft., it would have been well-warranted and would have prevented much of the trouble experienced from seepage and washouts.

From the rather meager data shown on the cross-section of this plant, it would appear that the suction pipes were belled at their extremities to about twice the cross-section area of the main portion of the pipes, and the discharge pipes do not appear to have been constructed with any increase in section at their outer ends. Prob-

ably a liberal increase in the section of both pipes would have assisted in regaining the velocity head to an amount which would justify the slight additional expense. I suggest study of the following clause which I am using in specifications for similar work:

"Suction and discharge pipes shall be increased in section so that the mean maximum velocities at the extremities farthest from the pump shall not exceed 4 ft. per sec."

It has been found by observation that a velocity of 4 ft. per sec. will retain in suspension the very fine matter usually coming to the pumps through the intake system of canals and will not scour out the material from which the discharge canals are usually excavated.

The article is in error in stating that the plant described is the largest drainage pumping plant in the country to be operated by electricity. The plant of the New Orleans Lake Shore Land Co., which was put into operation two years ago, exceeds it in both power and total capacity. This plant was designed by Prof. W. B. Gregory, of Tulane University, acting as consulting engineer, and the writer as engineer for the land company. The capacity of each of the duplicate units at normal head of 6 ft. is 76,000 gal. per min., with variation in static head from zero to 10 ft. Each unit consists of an inclosed-impeller pump (Worthington), driven through herringbone gears (Falk) with 10:1 ratio by a 230-hp. motor (General Electric), and a cycloidal vacuum pump (Wilbraham-Graham). The equipment was furnished and installed by A. M. Lockett & Co., Ltd., of New Orleans. No provision was made for collecting entrained water in the suction pipes of the priming units, as the pumps will pass a reasonable amount of water without injury to the machinery. Current is furnished by the New Orleans Railway and Light Co. at 2,200 volts. It is brought to the transformer house at the pumping station at 6,600 volts.

So far as my knowledge extends, this is the only electrically driven drainage pumping plant in use in this section for the drainage of agricultural lands. But this plant is insignificant in comparison with those of the City of New Orleans, which has approximately 24,000 acres under pump, practically all of which is served by electrically driven machinery. The present available capacity of such pumps in the city amounts to over 17,000,000 gal. per min. Contracts have been let and the installation commenced for eleven "Wood" screw pumps, each having a capacity of 225,000 gal. per min., as shown in *Engineering News*, Jan. 15, 1914. There is now available in the two central power stations of the Sewage and Water Board 11,000 hp. for operation of the electrically driven drainage pumps of the city.

A. M. Shaw.
Consulting Engineer.
Hibernia Building, New Orleans, La., Sept. 27, 1915.

Autogenous Welding Produces Strains in Metal

Sir—I have read with much interest your statement, on page 572 of the issue of Sept 16, in regard to the difficulties with bronze on the Catskill Aqueduct. I also read in the issue of Nov. 26, 1914, the original statement of the difficulties. The general subject is of great interest to me, but I am particularly interested in the statement that the cracks in the gate valves apparently result from "burning in," or welding.

It is well-known by those engaged in the manufacture of bronze and bronze alloys that unless the conditions of manufacture are properly controlled (and the most insignificant of these have at times an exceedingly important influence) the resulting alloys will not be satisfactory. It is necessary at times to resort to specific heat-treatments in order to obtain the results desired. If this fact is thoroughly appreciated, it is not to be wondered at that the change in structure caused by local heating, due to the burning-in, or welding, process, may entirely nullify the good qualities of the original piece.

It should also not be forgotten that there are undoubtedly strains set up because of the intense local heating and consequent intense local contraction which may not at the time of the repair be manifested. In cast-iron pieces such strains will generally make themselves known on the cooling off of the piece, by reason of the brittleness and low tensile strength of the material. In the case of the tougher materials, steel, bronze, etc., the strains still exist, although their manifestation in the form of cracks or distortion may not be noticed so soon or so prominently.

The changes in structure produced by the burning-in, or welding, processes are readily discovered by the microscope. Under certain conditions they are of no particular importance, but in the case under consideration they may be exceedingly serious. The writer does not pretend to say how such troubles should be overcome, because that is the province of the manufacturer and the engineer in charge of the work, but he does want to call attention to the frequent abuse of the oxyacetylene and electric-welding processes. This abuse generally comes through ignorance, but the extended application of these processes at the present time and the very great future possibilities of their application lead him to utter a word of warning, which is that such methods should not be used unless it is surely known that good results will be obtained.

It will also be found necessary to control in some way the operators who are doing the work, to be sure that the work they do is properly done. I appreciate the difficulty of doing this, but believe that it can be accomplished by careful selection of the men and by proper training. Welding processes have arrived at the stage where they are frequently considered to be applicable to any kind of repairs. This stage occurs in the use of all new processes, and until the limits of application of such a new process are determined difficulties will occur. Therefore the greatest caution should be used in permitting such work to be done, and before welding is employed assurance should be obtained that it can be done correctly and safely.

I cannot too strongly protest against the use of welding of any kind in connection with such parts as locomotive and car tires, where the entire structure of the metal is changed and strains set up which at some time will result in serious injury to property, and possibly loss of life. There is plenty of work that can be safely and economically done by these welding processes without straining them to arrive at results that, to say the least, are questionable in their permanency and safety.

S. W. Miller,
Rochester Welding Works.
406 Orchard St., Rochester, N. Y., Sept. 20, 1915.

Building Twin City Concrete Automobile Racetrack

SYNOPSIS—Grading work and concrete mixing and placing on new motor speedway at St. Paul.

The essential details of design of the concrete-paved Twin City Motor Speedway at Fort Snelling, between St. Paul and Minneapolis, Minn., were described in *Engineering News,* July 29, 1915, p. 233. This two-mile automobile racetrack was recently completed and tried out with a 400-mi. automobile race.

The trackway is 60 ft. wide on the straightaway opposite the grandstand and on the curves; on the straightaway in front of the grandstand it is 80 ft. wide. Along the inner side of the track is a macadamized apron 17 ft. wide, to be used for dead cars, changing tires, repairs, etc. The curves are eased by 800-ft. spirals. The track is oval, 3,865 ft. on the major and 2,500 ft. on the minor axis. The radius of the curves is approximately 1,250 ft. (See Fig. 1, p. 233, *Engineering News,* July 29, 1915.) The accompanying Fig. 1 shows a cross-section of the track on the curves.

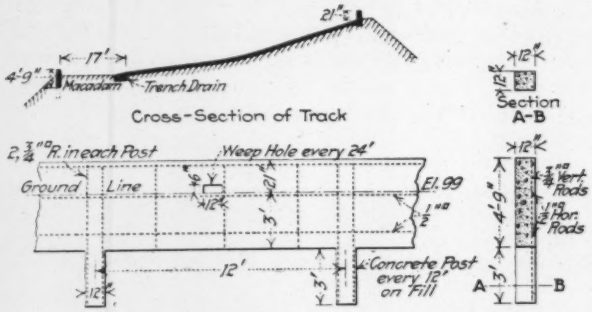


FIG. 1. CROSS-SECTION OF CONCRETE-PAVED RACETRACK; TWIN CITY MOTOR SPEEDWAY

The track was first graded to the proper width and form; the superelevation of the spirals and curves was made by earth fills. Fig. 2 shows the beginning of the grading operations. Excavations were made in the high parts of the field by steam shovels, and the earth was moved to the fills by narrow-gage railway trains. The earth was placed in layers and rolled with steam rollers. The specifications called for sprinkling, but rain fell practically every other day during the grading work, and while it was a serious hindrance to the contractor it was of great assistance in compacting the earthwork.

The 6-in. concrete pavement was laid by the use of three concrete mixers, two of 16-cu.ft. capacity and one of 14-cu.ft. The maximum output of any one machine in 10 hr. was 1,333 sq.yd. of pavement. The curbs, or retaining walls, along each edge of the trackway were built separately from the pavement, using three small mixers.

These retaining walls are 5 ft. high and 12 in. wide, and project 2½ ft. above the pavement. The wall around the outside track is reinforced by allowing 2½ ft. of the reinforcing rods to project out from the paving slab. These rods were bent up into the wall form when the walls were poured. It was the original intention to build the outer wall and paving at the same time. This did not work out well, and the wall was put in afterward, with its foundations under the paving, as shown in Fig. 1.

Paving work began July 9 with one machine, and on July 21 the grading had sufficiently progressed so that the second machine was put on. On Aug. 6 the third machine was put to work. All three machines were kept at work until the date of completion, Aug. 26.

The concrete was mixed 1 : 2½ : 4. As soon as a section of pavement was poured and surfaced to grade, a dry finish of 1 : 1 sand and cement was floated on top. The expansion joints were made by using "Elastite," ½ in. in thickness for the transverse diagonal joints (see *Engineering News,* July 29, 1915) and ¼ in. in thickness for the middle longitudinal joint running the entire length of the track.

On curves the outer 20 ft. of the pavement was reinforced with triangular "Trus Con. No. 20," and all pave-

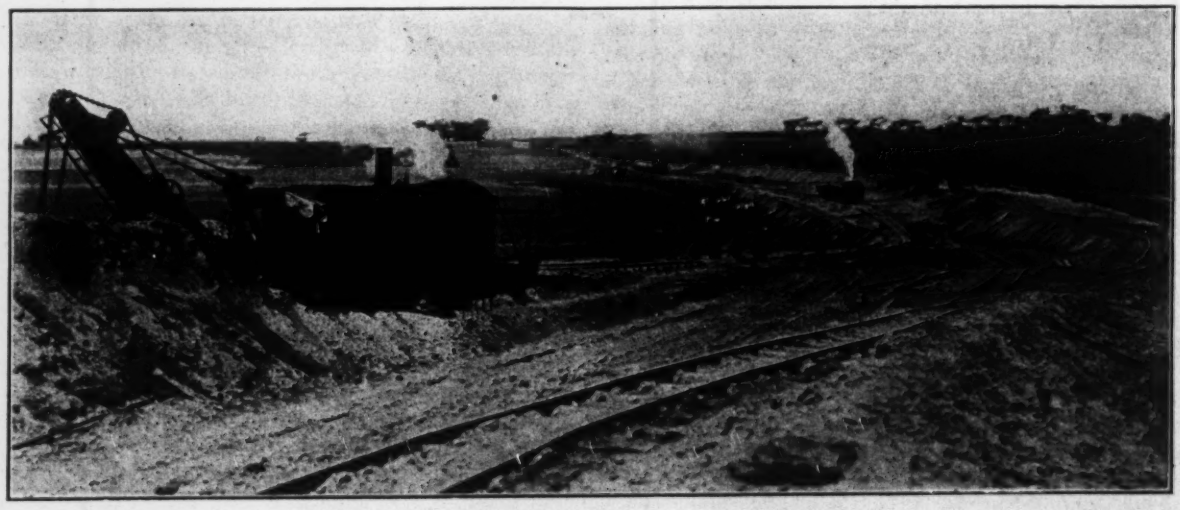


FIG. 2. GRADING TWIN CITY MOTOR SPEEDWAY, FORT SNELLING, MINN.

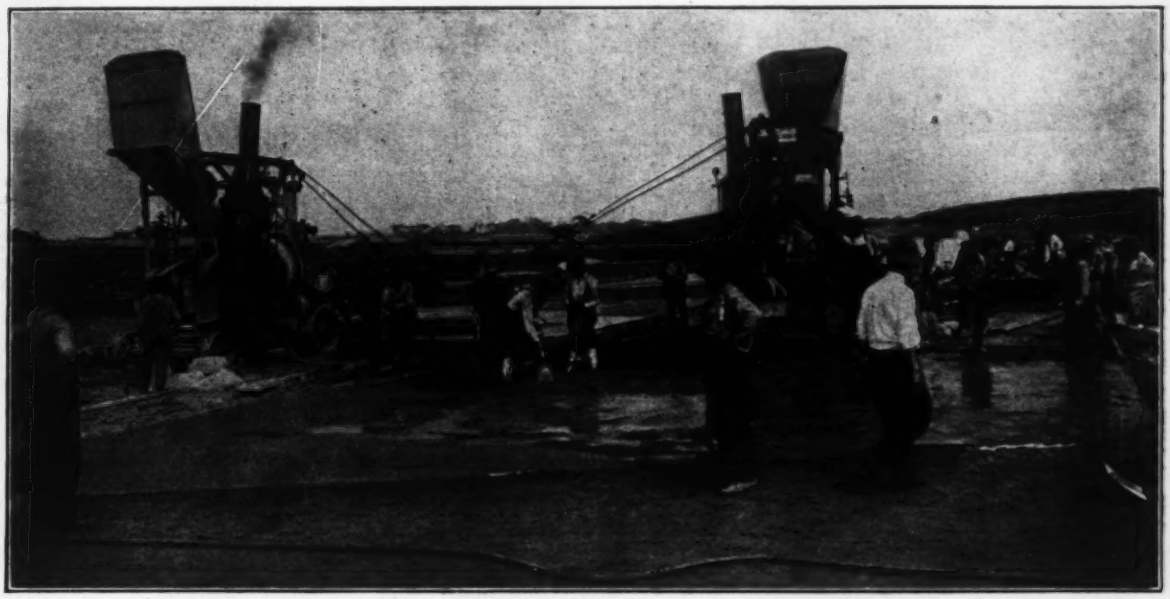


FIG. 3. POURING THE CONCRETE PAVEMENT, TWIN CITY MOTOR SPEEDWAY, FORT SNELLING, MINN.

ment was thus reinforced where the fill was over 4 ft. in height. The first 30 ft. of all pavement on each side of the entrance subways was also reinforced by use of ¾-in. twisted rods.

Crushed limestone was used, furnished by the St. Paul Crushed Stone Co. The stone was hauled 5 mi. in 5-cu.yd. motor trucks. Six loads a day was considered a day's work. A bonus was paid to the hauling contractor for all loads over six. In a single day one truck made 12 loads, or 120 mi. The sand for all concrete work was found on the ground and was of very good quality. A large part of it came out of the excavation for the entrance tunnels or subway. The crushed rock delivered by trucks was dumped in bins, from which it was loaded into 1¼-cu.yd. dump cars running beneath. An 18-in.-gage track circled the grounds with all necessary switches, side tracks, etc., and was used for the delivery of the stone and cement to the mixers.

A 2-in. pipe line was laid completely around the inside of the track to furnish water to the mixers. There were two feeder mains to this pipe, making the total length of 2-in. pipe three miles. One of the mains was supplied with water from a small lake by a 3x6-in. duplex pump driven by an 8-hp. gasoline engine. On the other main was a small duplex steam pump, which drew from a reservoir in the United States Military Reservation. The gas-engine plant did most of the pumping, and the steam plant was used to keep up the pressure to normal. There were many connections for hose and 1-in. pipe all around the circuit main.

The vitals on this job were the loading station and the pumping plant. With these two working perfectly, everything else was apparently easy. Different methods were tried of operating the paving mixers. An attempt was made to operate one machine along the 6-ft. berm at the top of fills and pave the outer slope for a width of 30 ft. The most successful method, and that ultimately followed, was to run the machines parallel on the trackway, each machine paving a strip 30 ft. wide.

All work was done hurriedly and under pressure. The concrete pavement was completed only ten days prior to the date on which the first great race was run over it. Some slight inequalities in the pavement, hardly discernible to the eye but found by racers in a trial race Sept. 2, had to be ground down and smoothed off.

The grandstands are of wood framing with concrete footings (see Fig. 4). The open boxes in the front part of the stands are furnished with six armchairs each, and in the grandstand behind the seats are fitted with opera-

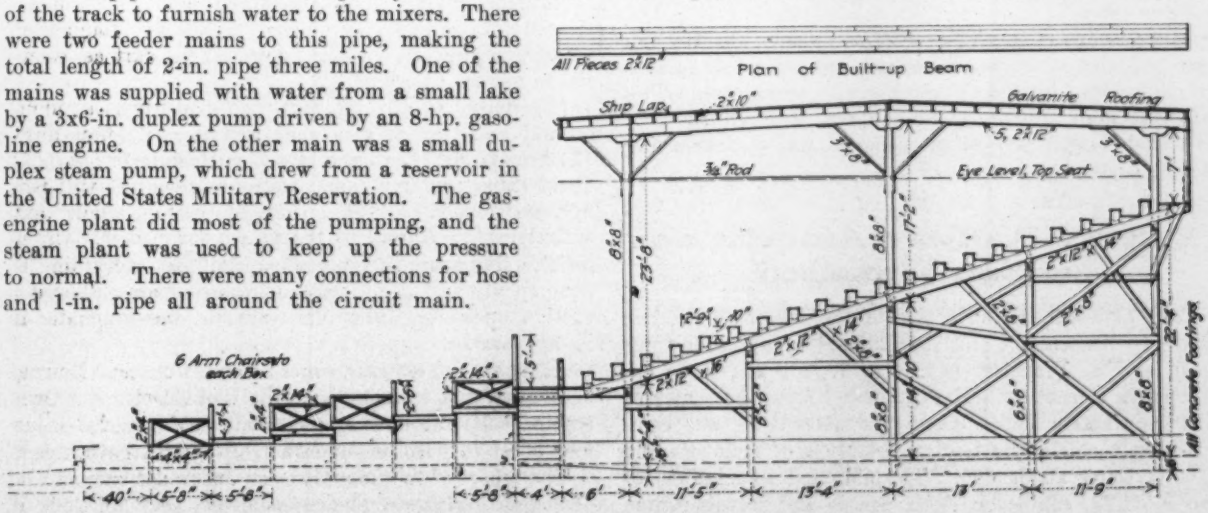


FIG. 4. CROSS-SECTION THROUGH TIMBER GRANDSTAND, TWIN CITY MOTOR SPEEDWAY

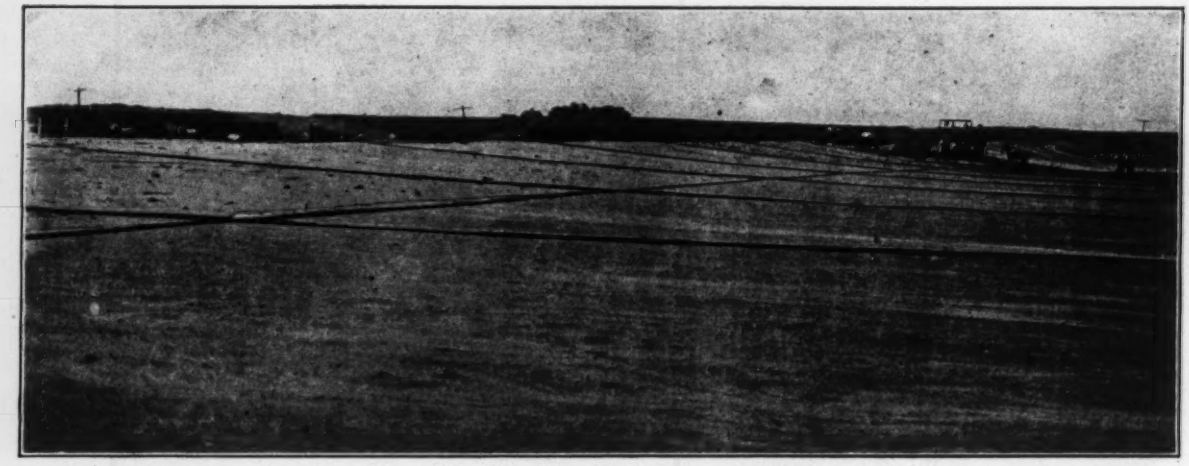


FIG. 6. COMPLETED PAVEMENT BEFORE EXPANSION JOINTS WERE TRIMMED

chair backs and arms. The grandstand roof is covered with "Galvanite" roofing made by the Ford Manufacturing Co., of St. Paul. In front of the grandstand is a 10-ft. wire fence on 2-in. wrought-iron pipe posts. The wire is 4x6-in. mesh. About 3,800,000 ft. b.m. of lumber was used in the grandstand and bleachers, and 300,000 ft. b.m. of lumber in fencing the grounds.

According to the local newspaper comment, the track as found by the racers on Sept. 4 was not so smooth as

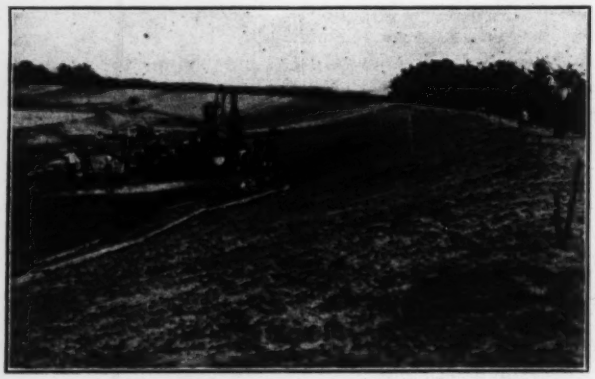


FIG. 5. CONCRETING PAVEMENT ON THE EARTH-FILL CURVES

was to be expected. The best speed made was 104 mi. per hr. Six of the 14 contestants did not finish because of engine trouble, broken valves, broken springs, etc. Tire changes were numerous; the 14 cars used up 78 tires. The hot, bright sun on the concrete was also annoying to the drivers.

Electric Railway Associations at San Francisco

The 34th annual convention of the American Electric Railway Association and its affiliated organizations was held at San Francisco Oct. 4 to 8. As was to be expected in a meeting held so far away from the center of electric-traction development, the attendance was comparatively small, the total registration of members and guests being about 650. The affiliated associations of accountants, engineers, claim agents and transportation and traffic officials held sessions each afternoon. The parent association's meetings occupied three forenoons. The usual exhibit of machinery and supplies was omitted on account of the exposition.

President C. Loomis Allen, in his presidential address, said that the previous troubles of the street-railway companies due to agitation for municipal ownership and to oppressive government regulation faded into insignificance compared with the financial difficulties experienced by street railways during the past year. The association's Bureau of Fare Research obtained figures from 25% of the large street-railway companies showing a drop in net earnings in the year ended June 30, 1915, of $2,800,000 compared with the previous year.

A feature of the first session was an address by Jesse W. Lilienthal, president of the United Railroads of San Francisco, reviewing the relations of the company with its employees and with the public during the two years of his presidency. The company has to compete with San Francisco's successful municipal electric railway, which under the terms of the city charter pays its employees $3 per day, a rate which the United company cannot afford. The company did, however, increase the wages to its men, furnished them with free life insurance without cost and without physical examination and established a loan system to save them from loan sharks.

Notwithstanding many discouragements and difficulties, Mr. Lilienthal still adhered to the five foundation principles which he had laid down at the start as essential to success, as follows:

(1) Accept loyally the fact that a utility is a public servant and that to give good service is its first duty. (2) Seek publicity, even in case of misfortune or loss. (3) Treat employees fairly, and as far as resources will permit, generously. (4) Keep out of politics, wholly and entirely. (5) Appeal to the public for justice. Circularize. Buy space in the newspapers. Let everything be done openly and in the name of the company. The discussion upon Mr. Lilienthal's address was emphatic in its approval.

At the second session former Senator Jonathan Bourne, of Oregon, gave an address on "Evils of Government Ownership." His argument was chiefly based on the injurious effect of government ownership on the government.

The report of the Committee on Insurance showed that 160 street-railway companies paid last year $964,000 in insurance premiums and incurred $202,000 in fire losses,

for which they received $168,000 insurance, or 17.35% of what they had paid out in premiums.

The Committee on Motor-Vehicle Operations reported a great falling off in the jitney competition. In 60 cities decreases of from 19 to 100% in jitney traffic were reported. Where reasonable public regulation of jitney traffic is established experience proves that the jitney disappears. The committee recommended that the association should undertake a thorough study of the motor bus of large passenger capacity.

At the final session most of the time was devoted to a paper by B. J. Arnold, of Chicago, on "Foundation Principles of Utility Valuation, with Special Application to Resettlement Plans." The paper is 40 pages in length and was hailed as an important contribution to this subject. In general Mr. Arnold urged that street-railway companies should seek to amortize their intangible property as rapidly as possible by devoting surplus earnings to extensions and improvements, so that when the properties are eventually taken over by the public their capitalization will represent no more than the physical value of the property.

Mr. Arnold's paper was also notable for its frank recognition that a radical readjustment of the relations between franchise companies and the public is inevitable and that a fair compromise is all the companies can hope for.

The nominating committee reported the following officers for the ensuing year and they were duly elected: President, Charles L. Henry, Indianapolis; vice-presidents, L. S. Storrs, New Haven; Timothy S. Williams, Brooklyn, and J. H. Pardee, Pottsville, Penn.

At the sessions held by the Engineering Association the time was chiefly devoted to routine work in connection with various details of operation and equipment which the association aims to standardize. Among the subjects taken up were lighting protection, power distribution, block signals, buildings and structures, life of railway physical property, power generation and electrolysis.

The new officers of the Engineering Association are: President, John Lindall (Boston Elevated Ry.); Vice-Presidents, F. R. Phillips (Pittsburgh Rys.), G. W. Palmer, Jr. (Bay State St. Ry.), and W. G. Gove (Brooklyn, N. Y., Rapid Transit System).

Granite-Block Crushing-Test Abandoned

The insufficiency and practical futility of a minimum crushing strength per square inch as a specification for granite paving blocks have been recognized in the standard specifications adopted by the American Society of Municipal Improvements at the recent Dayton convention. The impracticability of the crushing test and the fact that some of the smoothest and best granite-block pavements have been constructed of soft granites having a comparatively low compressive strength were discussed in the editorial on "Granite-Block Pavements" in *Engineering News* of Feb. 25, 1915. Much the same conclusions have been reached by the granite-block manufacturers after a thorough study and investigation of the subject by C. D. Pollock, Consulting Engineer, New York City.

The results of this investigation were placed before the society's subcommittee on granite blocks, and in the new specifications adopted by the subcommittee (and subsequently by the convention) the clause specifying a minimum crushing strength was omitted and specifications for testing the stone for toughness and abrasion were adopted. The testing methods to be employed are those described in Bulletin 44 of the United States Department of Agriculture on testing road materials. For heavy-traffic streets the coefficient of toughness is to be not less than 9 and the French coefficient of wear or abrasion not less than 11. For medium-traffic streets the same coefficients are 7 and 8 respectively.

Defects Caused by Gravel in Joints

In the discussion before the subcommittee on granite-block pavements and in a paper before the society Mr. Pollock demonstrated that the small defects which have occurred in some granite block pavements, caused by breaking or cracking of individual blocks, could in every case be traced to defective methods of filling the joints. These broken blocks were found to occur whether of so-called soft, medium or hard granite, and they occurred at points where the grouting appeared to be in perfect condition for a considerable distance in all directions about the broken blocks.

These failures are explained by Mr. Pollock as follows:

> The fracture of the blocks seemed to indicate that the cause was due to pressure from expansion. Where the grout was poor and broken out there were no broken blocks. Upon removing blocks at these pot-holes by beginning several blocks away from the broken ones, the grout was found to be good and had penetrated well down in the joints; but when the joint immediately adjacent to the broken block was reached, the grout proved to be good for only about 1 in. down from the top of the block and below this was either poor or the joint was filled simply with pea stone. In every case the break followed very closely the bottom line of the good portion of the grout. In other words, the top of the block had crushed and the bottom portion, where the grout was poor or missing entirely, remained intact.
>
> The blocks which had cracks across them like laminations proved to be whole and sound except for the top portion above the bottom line of the good grout. This all thoroughly backed up our theory that the cause of the fracture was the pressure concentrated upon the small area of the good grout. In fact, one sample was removed from about the center of an actual bulge in the pavement, which had lifted from the sand cushion sufficiently to be noticeable and to give forth a hollow sound when struck with a sledge. The fracture of the block was very recent and probably occurred during the extremely hot spell in September.
>
> Careful examination in many localities shows that these small defects in grouted granite-block pavements are not due to hard or soft stone but are the result of poor workmanship.
>
> The grout should be either uniformly poor or it should be uniformly good, preferably of course the latter. An even mixture should be used and the grout should penetrate the joints uniformly to a depth nowhere less than 3 in. With such a depth of good grout no blocks were found to have failed by crushing, not even where quite soft granite was used.
>
> Wherever possible the grout should be mixed by machines and care should be taken to secure a uniform product, like thin cream. The grout should be delivered into the joints directly from the machine by a spout or hose, so that the sand will not separate out, as it is very likely to do with transportation in wheelbarrows and the like.

The suggestions offered in the foregoing were considered by the subcommittee on granite-block pavements, and in the revised specifications gravel is not recommended for filling the lower half of the joints. The joints are to be filled from the bottom up with 1:1 portland-cement grout. A mortar bed in place of a sand cushion for bedding the blocks was considered, but the mortar bed was not approved by the society as a standard method of construction.